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(71) Applicant: **OMRON CORPORATION**
Kyoto-shi, Kyoto 616 (JP)

(72) Inventors:
- **Yamamoto, Norihito**
Ohtsu-city, Shiga-ken (JP)
- **Tanaka, Koichi**
Kyoto-city, Kyoto-fu (JP)
- **Hisano, Atsushi**
Kameoka-city, Kyoto-fu (JP)

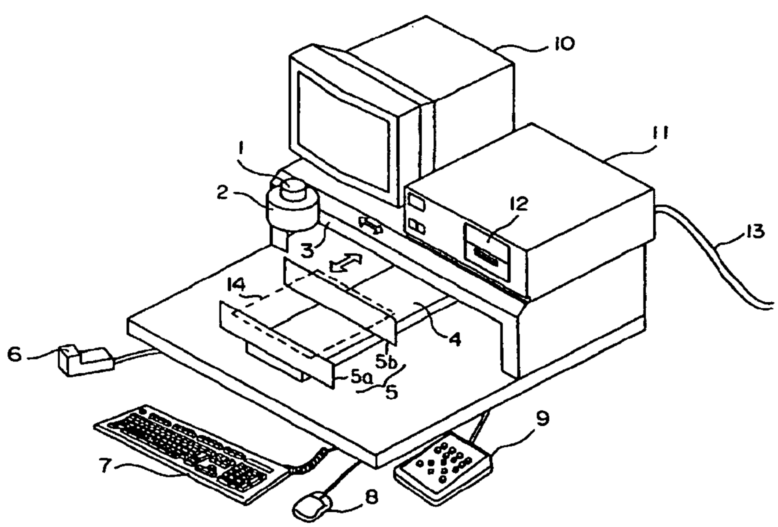
(74) Representative: **Kahler, Kurt, Dipl.-Ing.**
Patentanwälte
Kahler, Käck, Fiener et col.,
Vorderer Anger 268
86899 Landsberg/Lech (DE)

(54) Method and device to support in the repair of defective substrates

(57) This invention provides a method and device to support in the repair of substrates which would enable repairs to be performed efficiently.

A control unit (11) reads out of a floppy disk drive (12) or a network input/output unit the inspection results which include the defect file for substrate and stores them in a memory. This defect file is sorted into groups of components having the same defect code. In the order determined by this sorting, the defective components are moved by X-axis table (3) and Y-axis table (4) and imaged by imaging unit (1). The color image of each defective component is displayed on a monitor (10) along with its defect code. A layout diagram of the substrate is displayed to indicate the locations of the defective components. Components with the same defect code can be repaired consecutively.

FIGURE 1



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Description

Field Of The Invention

This invention concerns a method and device to support in the repair of defective portions of printed substrates on which various components are mounted, based on evaluation data obtained by inspecting those substrates.

Background of The Invention

Figure 40 illustrates the processes used to produce a substrate on which components are mounted when this invention is implemented. In Process A the components are mounted on the printed substrate; in Process B the components are soldered to the substrate, which is then sent to Process C.

In Process C, the mounting of each component is inspected based on data representing its location on the substrate. This inspection may be performed using a device which allows the appearance of the mounting to be evaluated by an inspector, or it may be performed by an automatic inspection device. In this case, the inspection device will create a defect file containing the result of the inspection for each substrate. A substrate with mounting defects will be sent with its defect file to Process D.

In Process D, the portions to be repaired are indicated, one by one, by the device to support in the repair, based on the aforesaid defect file. Each defect is repaired by hand according to the said indications.

The device to inspect substrates by eye consists of an X-axis table, a Y-axis table, an imaging unit, an illumination unit and a control processing unit. This control processing unit consists of a display, an input unit, a memory, a floppy disk drive and a control unit.

The X and Y-axis tables move the substrate in directions X and Y according to commands from the control unit so that portions of it can be successively imaged by the imaging unit.

The imaging unit successively images portions of the substrate. The illumination unit regulates the illumination of the vicinity around the component to be imaged according to commands from the control processing unit. The image signals output by the imaging unit are transmitted to the display by way of the control unit. The display unit displays the image of the component to be inspected.

The input unit is used to input the type of substrate being inspected, its ID number and the result of the evaluation of the component being inspected. The memory stores the data files needed to scan the components to be inspected. These files give the order in which the components are to be scanned.

The control unit reads out from the memory the data file containing the scanning order corresponding to the type of substrate which was input. Based on this scanning data file, it controls the X and Y-axis tables, the imaging unit and the illumination unit. For each substrate, it creates a defect file containing the result of the evaluation of each component input via the input unit and an image file showing the defective component on a layout diagram of all components to be inspected. It writes these defect and image files onto a floppy disk, and the disk drive causes the contents of these files to appear on the display.

Figure 41 is a flowchart of a visual inspection.

In Step 501, the identification of the substrate to be inspected (i.e., what type of substrate it is) is input by the operator. In Step 502, the control unit reads out of the memory the scanning file corresponding to the identification which was input.

In Step 503 the operator sets the substrate on the stage and in Step 503a he inputs its ID number. In Step 504, the control unit operates the X and Y-axis tables, images the first component and displays its image on the screen.

In Step 505, the operator views the image of the component on the display. If there is a soldering defect, he inputs a defect code in Step 506.

If in Step 507 the inspection of every component has not yet been completed, the image of the next component to be inspected is displayed in Step 508. We return to Step 505 and repeat the visual inspection. If in Step 507 all components have been inspected, a defect file is created in Step 509 for the substrate which has just been inspected. The contents of this file are displayed on the screen and an image file is created.

In Step 510 the substrate which was inspected is removed from the stage, and the inspection is over.

Figure 42 illustrates how the data are configured in the defect file created by the visual inspection device. Here component numbers 101 are given in the order of inspection. Component identification 102 is the identification code used by the inspection device for each component. Component class 103 is a code indicating the component's size, rating, etc. Coordinates 104 indicate the coordinates of the component's location on the substrate. Defect code 105 indicates the type of defect found in the visual inspection.

Figure 43 is a block diagram giving a sample configuration of an existing device to support in the repair of defective substrates. A floppy disk on which is stored the defect file for the substrate to be repaired is loaded in disk drive 107.

When the operator uses input unit 106 to enter the ID number of the substrate to be repaired, control unit 108 reads the defect file for that ID number out of floppy disk drive 107. The identification and class code, X and Y coordinates and defect code for the first defective component are shown on display 109.

The operator finds the defective component shown on the screen, repairs it, and enters via input unit 106 the fact that the repair has been completed. When the control unit receives the signal indicating that the repair has been completed, it displays the description of the defect for the second defective component in the defect

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file. The operator proceeds to repair this defect just as he did the first one.

With a prior art device to support in the repair of substrates, then, the result of the inspection by a visual inspection device is displayed on the screen, and the operator is given directions as to the location of the repair and the method which should be used.

With the existing method and device to support in the repair of substrates as described above, the defective components are displayed in the same order in which they were discovered in the inspection performed by the visual inspection device. For this reason, various defect phenomena (corresponding to different defect codes) are displayed in random order. The operator might need a soldering iron to repair the first component, change to a solder sucker to repair the next, and change back to a soldering iron to repair the third. This makes the repair of defective portions inefficient.

In addition, an inexperienced operator might choose a tool which is inappropriate for the type of repair which needs to be done or he might require a period of time to make the choice.

Another problem is that for each repair, the substrate must be moved from the imaging site to the repair site. The operator must then locate on the actual substrate the defective component which he sees on the screen, which requires time and labor.

If a substrate required an inordinate amount of time to repair, it would sometimes be more efficient, from the point of view of cost, not to repair it.

Summary Of The Invention

This invention addresses the difficulties of prior art devices discussed above. Its objective was to provide a method and device to support in the repair of substrates which would allow the repairs to be performed more efficiently.

In order to achieve the objective stated above, the method to support in the repair of substrates according to this invention was designed so as to entail: a process in which data concerning defective portions of the substrate which were created during the inspection process are stored in a storage device; a process in which the aforesaid defect data are sorted by a data sorting device into sets of data representing the same sort of defect or the same sort of required repair; and a process in which an indicating device points out the locations of defects on the substrate in the order determined by sorting the data in the aforesaid sorting process. The device to support in the repair of substrates according to this invention is equipped with: a device to store data concerning defective portions of the substrate which were created by the inspection device; a device to sort the aforesaid defect data into sets of data representing the same sort of defect or the same sort of required repair; and a device to point out the locations of defects on the substrate in the order determined by the aforesaid data sorting device.

In the method to support in the repair of substrates disclosed in Claim 4 of this application, the aforesaid process of indicating the locations of defects entails the following. A spot on the substrate where a defect is to be highlighted is moved into highlighting position by a positioner, and the location of the defect on the substrate is indicated by projecting a spotlight onto the defective portion. The device to support in the repair of substrates disclosed in Claim 15 of this application is equipped with a device to move the substrate so as to successively position each defective part in the order determined when the data were sorted by the aforesaid sorting device. The aforesaid indicating device points out the defective part moved by the positioner into the aforesaid highlighting position by projecting a spotlight onto it.

In the method to support in the repair of substrates disclosed in Claim 5 of this application, the aforesaid indicating process consists of highlighting the location of each defect on the substrate in the order determined by the aforesaid data sorting process, and consists also of specifying the type of repair to be performed and the tool to be used. In the device to support in the repair of substrates disclosed in Claim 16 of this application, the aforesaid indicating device highlights the location of each defect on the substrate in the order determined by the aforesaid data sorting process and also specifies the type of repair to be performed and the tool to be used.

In the method to support in the repair of substrates disclosed in Claim 11 of this application, after the aforesaid data recording process has been completed, the data associated with the defective portions of the aforesaid substrates are used to calculate, for each substrate, the total repair time it will require. Codes are then displayed identifying the substrates in the order of their repair time, beginning with the shortest time required. A warning is issued for any substrate whose total repair time exceeds a previously established limit. The device to support in the repair of substrates disclosed in Claim 23 of this application calculates the total repair time which will be needed for each board, and it displays codes identifying the substrates in the order of their repair time, beginning with the shortest time required. It also has an evaluation device which issues a warning for any substrate whose total repair time exceeds a previously established limit.

With the method and device of this invention, then, data representing defective portions of a substrate are recorded and the recorded defect data are sorted according to type of defect or type of repair needed. The locations of the defects on the substrate are indicated in the order determined by sorting the data. This enhances the efficiency of the repair operation.

With the method described in Claim 4 and the device described in Claim 15, the locations of defects to be repaired on the substrate are indicated by means of a spotlight, which allows the substrate to be repaired more efficiently.

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With the method described in Claim 5 and the device described in Claim 16, the type of repair to be performed and the tool to be used are specified, which allows the substrate to be repaired more efficiently.

With the method described in Claim 11 and the device described in Claim 23, the data associated with the defective portions of the aforesaid substrates are used to calculate, for each substrate, the total repair time it will require. Codes are then displayed identifying the substrates in the order of their repair time, beginning with the shortest time required. A warning is issued for any substrate whose total repair time exceeds a previously established limit. Substrates which would require too much time to repair can be eliminated to improve cost efficiency.

Brief Description Of The Invention

Figure 1 is a sketch of the first ideal embodiment of this invention.

Figure 2 is a diagram of the overall configuration of the repair device which is the first ideal embodiment of this invention.

Figure 3 illustrates the configuration and the operating principle of the trichromatic light source in illumination unit 2.

Figure 4 illustrates the configuration of a system which includes this invention and an inspection device (when the inspection results are supplied by means of a floppy disk).

Figure 5 illustrates the configuration of a system which includes this invention and an inspection device (when the inspection results are supplied by means of a LAN).

Figure 6 is a flowchart of the order of processing executed by the repair device in the first ideal embodiment of this invention.

Figure 7 is a subroutine of the flowchart shown in Figure 6. It shows the order of processing involved in stipulating the sorting conditions.

Figure 8 is a subroutine of the flowchart shown in Figure 6. It shows the order of processing involved in reading out the inspection results.

Figure 9 is a subroutine of the flowchart shown in Figure 6. It shows the order of processing involved in repairing the substrate.

Figure 10 is the screen displayed on the monitor to set "Sort Data."

Figure 11 is the screen displayed on the monitor to set defect codes.

Figure 12 is the screen displayed on the monitor to change the settings for defect codes.

Figure 13 is the screen displayed on the monitor to set the order in which defect codes are to be sorted.

Figure 14 is a layout diagram created from an image file.

Figure 15 is the screen displayed on the monitor to show the operator data concerning defective components.

Figure 16 illustrates how the data may be configured in defect files.

(a) shows how the data are configured in the defect file before being sorted by defect code.
(b) shows how the data are configured in the defect file after being sorted by defect code.
(c) shows how the data are configured in the defect file partway through the repair operation.

Figure 17 is a sketch of the second ideal embodiment of this invention.

Figure 18 is a plan view of the second ideal embodiment of this invention. It shows the positions into which the X and Y tables can be moved.

(a) shows the position in which the substrate is loaded and unloaded and its defective portions are repaired.
(b) shows the position in which the defective portion of the substrate is imaged.
(c) shows the position in which the defective portion of the substrate is highlighted by a spotlight.

Figure 19 is a lateral view of the second ideal embodiment of this invention.

Figure 20 is a cross section of the optical highlighter.

Figure 21 is a flowchart of the processing executed by the repair device in the second ideal embodiment of this invention.

Figure 22 is a subroutine of the flowchart in Figure 21. It shows the order of processing executed to stipulate the sorting conditions.

Figure 23 is a subroutine of the flowchart in Figure 21. It shows the order of processing executed to read out the inspection results.

Figure 24 is a subroutine of the flowchart in Figure 21. It shows the order of processing executed to repair the substrate.

Figure 25 is a subroutine of the flowchart in Figure 24. It shows the order of processing executed to repair a defective component.

Figure 26 is a diagram of the overall configuration of the repair device which is the third ideal embodiment of this invention.

Figure 27 is a flowchart of the order of processing executed by the repair device in the third ideal embodiment of this invention.

Figure 28 is a subroutine of the flowchart shown in Figure 27. It shows the order of processing involved in stipulating the sorting conditions.

Figure 29 is a subroutine of the flowchart shown in Figure 27. It shows the order of processing involved in reading out the inspection results.

Figure 30 is a subroutine of the flowchart shown in Figure 27. It shows the order of processing involved in repairing the substrate.

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Figure 31 shows the screen displayed on the monitor to set the type of repair and the repair tool for each defect code.

Figure 32 shows the screen displayed on the monitor to set the method by which the data are to be sorted.

Figure 33 shows the screen displayed on the monitor to set "Sort Data by Type of Repair Needed."

Figure 34 shows the screen displayed on the monitor in the third ideal embodiment of this invention to show the operator data concerning defective components.

Figure 35 is a flowchart of the order of processing executed by the fourth ideal embodiment of this invention to produce repair time data.

Figure 36 is a subroutine of the flowchart in Figure 35. It shows the order of processing involved in reading out a batch of inspection results.

Figure 37 is a subroutine of the flowchart in Figure 35. It shows the order of processing executed by the repair device.

Figure 38 is the screen displayed on the monitor to set a repair time for each defect code.

Figure 39 is the screen displayed on the monitor to show the operator the repair time data.

Figure 40 is a block diagram of the processes involved in producing a substrate with components mounted on it.

Figure 41 is a flowchart of the inspection of a substrate by the inspection device.

Figure 42 shows how the data are configured in the defect file created by the inspection device.

Figure 43 is a block diagram of the configuration of a device to support in the repair of substrates belonging to the prior art.

Detail Description Of The invention

Figure 1 is a sketch of our first example of an ideal embodiment of this invention. In this drawing 1 is the imaging unit; 2 is the illumination unit, which illuminates the portion of the substrate which is to be imaged by unit 1; 3 is the X-axis table; 4 is the Y-axis table; 5 is the stage for the substrate; 6 is a bar code reader; 7 is a keyboard; 8 is a mouse; 9 is the operating keyboard; 10 is a monitor; 11 is a controller; 12 is a floppy disk drive; and 13 is a LAN cable.

Imaging unit 1 is a color television camera. Illumination unit 2 is of a single piece with imaging unit 1 and is mounted on X-axis table 3.

X-axis table 3 has a motor (not pictured) and a moving frame (not pictured) inside a fixed rectangular frame. Imaging unit 1 and illumination unit 2, which are formed as a single piece, are mounted on the moving frame. When the aforesaid motor is driven forward and in reverse, imaging unit 1 and illumination unit 2 are moved forward and backward along with the moving frame in a straight line in direction X.

Stage 5 consists of two parallel supports, 5a and 5b, which hold substrate 14 as shown in the drawing. These supports are mounted to Y-axis table 4.

Y-axis table 4 is orthogonal to X-axis table 3. It has a fixed rectangular frame which contains a motor and a moving frame (not pictured). Stage 5 is mounted to this moving frame. When the aforesaid motor is driven forward or in reverse, stage 5 moves back and forth with the moving frame in a straight line in direction Y.

Figure 2 shows the overall configuration of the first ideal embodiment of this invention. As can be seen from the drawing, this device comprises imaging unit 1, illumination unit 2, X-axis table 3, Y-axis table 4, stage 5 and control processing unit 27.

Illumination unit 2 consists of a trichromatic light source composed of three annular light sources, 24, 25 and 26, each of which emits one of a red, green or blue light.

Figure 3 illustrates the configuration and the operating principle of the trichromatic light source in illumination unit 2. In Figure 3, the aforesaid annular light sources 24, 25 and 26 are placed concentrically so that the central axis e of imaging passes through their center point. When the radius of the annular light source and its height are varied, the angle of incidence of the beam with respect to imaging axis e will vary, and three angles will result, which we shall call θ_1, θ_2 and θ_3.

Illumination unit 2, which is configured as described above, illuminates solder F on component E, which is mounted on substrate 14. If we assume that solder F is a reflective surface, the light which strikes the solder at incident angle θ_1 will be reflected by a portion of the solder with a given angle of inclination. The angle of inclination λ_1 of the portion of the surface which reflects this light along path e, which is the imaging axis, will be different from the angle of inclination λ_2 of the portion of the surface which reflects a beam with an angle of incidence of θ_2 in axial direction e. Likewise, the angle of inclination λ_3 of the portion of the surface which reflects a beam with an angle of incidence of θ_3 in axial direction e will differ from both λ_1 and λ_2. Solder F normally has a curved surface. A beam which strikes at angle of incidence θ_1 the portion of solder F which we may consider to have an approximate angle of inclination of λ_1 will be reflected in direction e, along the axis of imaging. A beam which strikes at angle of incidence θ_2 the portion of solder F which we may consider to have an approximate angle of inclination of λ_2 will also be reflected in axial direction e.

Solder F is accordingly imaged by imaging unit 1 and its image is displayed on monitor 10. A portion of the solder will appear to be red; another portion with a different angle of inclination will appear to be green; another portion with yet a third angle of inclination will appear to be blue. From this tricolor image, the operator is able to determine the shape of solder F.

To give an example, let us assume that annular light source 24 emits red light, light source 25 emits green, and light source 26 emits blue light. In the colored

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image, the portion of solder F with the smallest angle of inclination will be red, the portion with the greatest angle of inclination will be blue, and the portion with an intermediate angle of inclination will be green.

To return to Figure 2, control processing unit 27 consists of controller 16 for imaging and illumination; X and Y table controller 17; monitor 10; memory 15; floppy disk drive 12; input unit 22; bar code reader 6; network input and output unit 18; and control unit 23. Of these components, controller 16, X and Y table controller 17, memory 15, floppy disk drive 12, network input and output unit 18 and control unit 23 are housed within controller 11, which is shown in Figure 1. Input unit 22 comprises keyboard 7, mouse 8 and operating keyboard 9.

Controller 16 controls the imaging operation performed by imaging unit 1 and the emission of light by light sources 24, 25 and 26 in illumination unit 2 according to commands from control unit 23. The image signals representing the component to be repaired which are output by imaging unit 1 are converted to color video signals and transmitted to control unit 23.

X and Y table controller 17 controls the operation of X-axis table 3 and Y-axis table 4 in response to commands from control unit 23.

Monitor 10 displays the colored image of the component to be repaired produced by imaging unit 1, a diagram of the layout of the substrate to be repaired and various necessary data, all of which it receives from control unit 23.

Memory 15 stores the program which operates this invention. In it are also stored the defect files transmitted by control unit 23, image files and various other data.

Keyboard 7, mouse 8 and operating keyboard 9 in input unit 22 may be used as needed by the operator to input various data. Operating keyboard 9 has keys for which there is a specific need (such as keys to enter the defect code) and is independent from keyboard 7. Bar code reader 6 reads the bar code on each substrate to be repaired to determine the ID number of that substrate. This ID number can then be entered via keyboard 7.

Floppy disk drive 12 reads defect and image files created by the inspection device off a floppy disk in response to a command from control unit 23. It also writes onto a floppy disk defect files created by control unit 23.

Network input and output unit 18 is connected to LAN cable 13. In response to a command from control unit 23, it takes from a network via LAN cable 13 defect and image files created by the inspection device. It also transmits to the network via LAN cable 13 defect files created by control unit 23.

Depending on the way in which the system which includes the inspection device is configured, either the aforesaid floppy disk drive 12 or network input and output unit 18 may be used. Figures 4 and 5 illustrate two ways a system connected to an inspection device might be configured. Figure 4 shows a system mediated by a floppy disk; Figure 5 shows a system using a LAN.

In Figure 4 the defect and image files created by inspection device 30 are transmitted to data acquisition terminal 33 by way of a transmission line such as an RS-232C. Data acquisition terminal 33 stores the defect and image files it acquires on floppy disk 34. The defect and image files are supplied to repair device 31 by way of floppy disk 34.

In Figure 5 the defect and image files acquired via data acquisition terminal 33 through LAN cable 36 are transmitted to server 35, a hard disk or the like, by way of the same LAN cable 36 and stored there. Repair device 31 reads out of server 35 the necessary defect and image files.

Returning again to Figure 2, control unit 23 contains a microprocessor. According to a program which it reads out of memory 15, it controls the overall operation of the various components of control processing unit 27, performs various operations and edits defect and image files.

Figure 6 is a flowchart of the processing performed by the first ideal embodiment of this invention. Figure 7 shows the subroutines in Steps 2 and 7 in Figure 6. It is a flowchart of how the sorting conditions are set. Figure 8 is the subroutine in Step 3 in Figure 6. It is a flowchart showing the order of processing involved in reading out inspection results. Figure 9 is the subroutine in Step 10 in Figure 6. It is a flowchart giving the order of the repair operation.

In Step 1 of Figure 6, the operator inputs whether to sort the data concerning defective components in the defect file according to their defect codes. The "set data sorting" screen shown in Figure 10 is displayed on monitor 10. The operator clicks on input window 29 with mouse 8 shown in Figure 1 to set whether to sort the data. If he clicks on "Sort Data" in input window 29, it will change to "Do Not Sort Data." When the setting has been completed, the operator must click on "OK."

If in Step 1 the operator has input "Do Not Sort Data," we proceed to Step 3. If he has input "Sort Data," we proceed to Step 2.

In Step 2, the conditions for sorting the data are set. Because a wide variety of defect codes (hereafter, "inspection defect codes") is assigned by the inspection device, in Step 16 of Figure 7 these inspection defect codes are sorted, and independent defect codes are set anew for the repair device. Figure 11 shows the screen displayed on the monitor for setting defect codes.

In Step 17 of Figure 7, the inspection defect codes are converted to the defect codes which were set in Step 16. Figure 12 shows the screen displayed on the monitor to convert the defect codes. In this figure, 37 shows the inspection defect codes and 38 the defect codes used by the repair device. For example, the inspection defect code 01, "not much fret," is converted to the defect code 2, "no solder," for the repair device.

In Step 18 of Figure 7, the order in which the defect codes will be sorted is set. We then proceed to Step 3 in

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Figure 6. Figure 13 shows the screen which appears on the monitor to set the order in which defect codes will be sorted. For these defect data, data representing components with a defect code of 2, "no solder," are to be sorted first, followed by those with a code of 3, "bridge." Data for components having the same defect code will be sorted in increasing order by part number. In other words, they will be arranged in the same order in which they were inspected.

In Step 3 of Figure 6, the defect and image files showing the results of the inspection are read out. In Step 19 of Figure 8, the operator inputs the ID number of the substrate to be repaired using either bar code reader 6 or keyboard 7, as shown in Figure 1. In Step 20, control unit 23 reads off the floppy disk or LAN server the defect and image files for the ID number which was input.

Returning to Figure 6, in Step 4 control unit 23 sorts the data in the defect file according to the conditions stipulated in Step 2. We then proceed to Step 5. However, if "Do Not Sort Data" was input in Step 1 and sorting conditions were not stipulated in Step 2, the data will not be sorted.

In Step 5, the operator places the substrate to be repaired on stage 5.

In Step 6, if the sorting conditions are not to be modified, the operator inputs "No," and we proceed to Step 9. If the operator inputs "Yes" in this step to signify that he wishes to modify the sorting conditions, we proceed to the processing in Steps 7 and 8, which will be discussed shortly.

In Step 9, control unit 23 moves X-axis table 3 and Y-axis table 4 until the first defective component from the defect file which was sorted is in imaging position, directly below imaging unit 1. The defect data for the component, which consist of the color image of the component captured by imaging unit 1, its defect code and a diagram showing the layout of components on the substrate which was created from data in the image file, are all displayed on monitor 10.

Figure 14 is a layout diagram created from data in the image file. In this figure, the regions indicated by broken or solid lines represent components mounted on the substrate. Components shown by solid lines are those which were judged to be defective by the inspection device. ICs are divided into several regions for the purpose of inspection. Each region may be shown with broken or solid lines.

Figure 15 shows the defect data screen displayed on the monitor. In this figure, 39 is the camera frame in which the color image of the defective component captured by imaging unit 1 is displayed. 40 is a layout diagram displayed in a camera frame to indicate where on the substrate the defective components are. It uses the layout diagram shown in Figure 14, and distinguishes the defective components in some way (for example, by coloring them or using arrows to point to them). 41 is the identification code for the defective component which is displayed on the camera frame. 42 is the description of the defect which corresponds to the defect code for this component. 43 is the command menu. In the repair operation in Step 10 of Figure 6, items are selected from the menu by clicking on them with mouse 8.

Returning to Figure 6, in Step 10 the operator performs the repair while viewing the defect display screen. Specifically, in Step 21 of Figure 9, the operator views the camera frame on monitor 10 to check the condition of the defect. In Step 22, if he determines that the defect code displayed on monitor 10 is the correct one, he proceeds to Step 24. If he determines that the code is wrong or that the location of the defect does not exist, he changes or cancels the defect code in Step 23 before proceeding to Step 24.

In Step 24, the operator inputs whether he will repair this component. If he will not, he proceeds to Step 34. If he will, he proceeds to Step 25.

In Step 25 the operator inputs the command to move the substrate to the repair site (the site where it is loaded and unloaded). In Step 26, control unit 23 freezes a camera frame on monitor 10. In Step 27, the substrate is moved to the repair site.

In Step 28, the operator consults the layout diagram displayed on monitor 10, finds the defective component and repairs it. In Step 29 he inputs the command to move the substrate to the imaging site. In Step 30, control unit 23 moves the substrate to the imaging site and images the component a second time. In Step 31 a color image of the component is overlaid on the camera frame.

In Step 32, the operator checks the portion he has just repaired on the camera frame. In Step 33, he inputs whether further repairs are required. If the response is "yes," he returns to Steps 25 through 32. If the response is "no," he proceeds to Step 34.

In Step 34, the operator inputs the fact that the repair of this component, that is, of the first defective component in the defect file, has been completed. He then proceeds to Step 11 in Figure 6.

In Step 11, if there is another defective component, he returns to Step 6. If he wishes to modify the sorting conditions, meaning the defect code and the sorting order, he inputs "yes." In Step 7 he stipulates new sorting conditions. In Step 8 the defect data are sorted according to the new conditions, and he proceeds to Step 9. If he does not need to modify the sorting conditions, he immediately proceeds to Step 9. The processing in Step 7 is the same as that in Step 2, and that in Step 8 is the same as that in Step 4 except for the fact that when the data are sorted in Step 8, components which have already been repaired are eliminated.

In Steps 9 and 10, the next defective component is processed just as the first one was This component will be the second defective component resulting from the sorting in Step 2 or the first defective component resulting from the sorting in Step 8.

The processing in Steps 6 through 10 is repeated. If in Step 11 all defective components have been repaired, in Step 12 control unit 23 writes onto the

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floppy disk or LAN server the edited defect and image files, which are kept separate from those created by the inspection device. These edited files include files whose defect data have been sorted, files which have been given defect codes or flagged by the repair device when their repairs were completed, defect files in which defect codes mistakenly assigned by the inspection device have been corrected, and image files which have been corrected along with these defect files.

Figure 16 illustrates how the data are configured in defect files. 16 (a) shows the configuration of the data in a defect file in the inspection device before they are sorted according to defect code. (b) shows the configuration after the data have been sorted according to defect code. (c) shows the configuration of the data in the defect file partway through the repair operation. In (c), an asterisk in the "Repaired" column indicates that the repair has been completed, and a dash indicates that it has not.

In Step 13 of Figure 6, the operator inputs the command to move the substrate to the loading and unloading site and it is moved to the site and removed from stage 5. In Step 14, the operator inputs whether he will repair another substrate. If he inputs "Yes," he returns to Step 3, and the new substrate is processed just as the previous one was.

With the ideal embodiment of this invention described above, defect data are sorted according to defect code. The operator is instructed to repair the defective components in the order into which they were sorted. This method allows all components which have the same type of defect to be repaired consecutively, so the operator does not need to repeatedly pick up a different repair tool. The repair operation can be performed more efficiently.

Figure 17 is a sketch of a second ideal embodiment of this invention. With the exception of optical highlighter 28, all the components in the drawing are the same as those in the previous embodiment. They have been given the same numbers and will not be discussed further at this point.

The overall configuration of the second ideal embodiment of this invention is identical to that of the first embodiment, which is shown in Figure 2, with the addition of optical highlighter 28. Imaging and illumination controller 16 is replaced by controller 47, memory 15 by memory 48, control unit 23 by control unit 49, and control processing unit 27 by control processing unit 50.

Imaging and illumination controller 47 controls the imaging operation performed by imaging unit 1, the emission of light by illumination unit 2, and the actuation and deactuation of optical highlighter 28. The signal representing the image of the component to be repaired which is output by imaging unit 1 is converted to a color video signal and transmitted to control unit 49.

Memory 48 stores the repair program needed to run this invention. It also stores the defect and image files sent from control unit 49 and a variety of other data.

Control unit 49 contains a microprocessor. According to the repair program which it reads out of memory 48, it controls the overall operation of the various components of control processing unit 50, creates defect data, performs various operations and edits defect and image files.

Figure 18 is a plan view illustrating the operation of X-axis stage 3 and Y-axis stage 4 in the second ideal embodiment of this invention. It shows a substrate loaded on stage 5. (a) shows the site where substrate 14 is loaded and where the defective portion of component E (marked with an x) will be repaired. (b) shows the site where the defective portion will be imaged. (c) shows the location where the defective portion will be highlighted by a spotlight. Figure 19 is a lateral view of the second embodiment. Figure 20 is a cross section of optical highlighter 28.

As is shown in Figure 20, highlighter 28 has a light source 44, such as an LED, and a condenser 45, which condenses the beam emitted by the light source, causing a spotlight to be projected onto the surface of substrate 46. When the substrate is moved to the highlighting location shown in Figure 18 (c), imaging and illumination controller 47 actuates the light source, and the defective portion is highlighted by a spotlight.

In the second ideal embodiment of this invention, optical highlighter 28 is mounted to the side of illumination unit 2, as shown in Figures 17 and 19. The spotlight is made to strike the substrate perpendicularly. The location in which highlighter 28 is mounted and the highlighted location shown in Figure 18 (c) should be adjusted so that the operator can repair the defective portion while the defect is highlighted by the spotlight. That is, it is desirable that the spotlight be located so that the operator can easily repair the component.

Figure 21 is a flowchart of the processing performed by the second ideal embodiment of this invention. Figure 22 is the subroutine in Steps 37 and 42 of Figure 21. It is a flowchart of the steps entailed in stipulating the conditions for sorting. Figure 23 is the subroutine in Step 38 of Figure 21. It is a flowchart of the processing involved in reading out the inspection result. Figure 24 is the subroutine in Step 45 of Figure 21. It is a flowchart of the processing involved in repairing the substrate. Figure 25 is the subroutine in Step 59 of Figure 24. It is a flowchart of the processing involved in repairing each defective component.

In Step 36 of Figure 21, the operator inputs whether to sort the data in the defect file according to defect codes (See Figure 10).

If in Step 36 the choice was made not to sort the data, we proceed to Step 38. If the choice was made to sort the data, we proceed to Step 37.

In Step 37, the operator stipulates the conditions which govern sorting the data. Because a wide variety of defect codes is assigned by the inspection device, in Step 50 of Figure 22 these inspection defect codes are sorted, and independent defect codes are set for the repair device (See Figure 11).

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In Step 51, the operator adjusts the settings so that the defect codes assigned by the inspection device can be converted to the defect codes used by the repair device which were established in Step 16 (See Figure 12).

In Step 52, the operator sets the order in which the defect codes are to be sorted (See Figure 13), and we proceed to Step 38 in Figure 21.

In Step 38 of Figure 21, the result of the inspection performed by the inspection device is displayed and the defect and image files are read out. In Step 53 of Figure 23, the operator inputs the ID number of the substrate to be repaired using either bar code reader 6 or keyboard 7. In Step 54, control unit 49 reads the defect and image files for the ID number which was input off the floppy disk or LAN server.

Returning to Figure 21, in Step 39 control unit 49 sorts the data in the defect file according to the conditions stipulated in Step 37. We then proceed to Step 40. However, if "Do Not Sort Data" was input in Step 36 or sorting conditions were not stipulated in Step 37, the data will not be sorted.

In Step 40, the operator places the substrate to be repaired on stage 5.

In Step 41, if the sorting conditions are not to be modified, the operator inputs "No," and we proceed to Step 44.

If in Step 41 the operator wishes to modify the sorting conditions, i.e., to modify the settings for the defect codes or the sorting order, he inputs "Yes." In Step 42 he stipulates new sorting conditions. In Step 43 the defect data are sorted according to the new conditions, and we proceed to Step 44. The processing in Step 42 is the same as that in Step 37, and that in Step 43 is the same as that in Step 38. If from Step 46 we proceed to the processing in Step 43 by way of Steps 41 and 42, the components which have already been repaired will be eliminated from the data to be sorted.

In Step 44, control unit 49 moves X-axis table 3 and Y-axis table 4 until the first defective component from the defect file which was sorted is in imaging position, directly below imaging unit 1. The defect data for the component, consisting of the color image of the component captured by imaging unit 1, the defect code for this component and a diagram showing the layout of components on the substrate which was created from data in the image file, are all displayed on monitor 10 (See Figure 15).

In Step 45 the operator performs the repair while viewing the defect display screen. Specifically, in the subroutine shown in Figure 24, in Step 55 the operator views the camera frame on monitor 10 to check the condition of the defect. In Step 56, if he determines that the defect code displayed on monitor 10 is the correct one, we proceed to Step 58. If he determines that the code is wrong or that the location of the defect does not exist, he changes or cancels the defect code in Step 57 before proceeding to Step 58.

In Step 58, the operator inputs whether he will repair this component. If he will not, we proceed to Step 60. If he will, we proceed to Step 59.

In Step 59 the operator repairs the defective component. That is to say, in Step 62 of Figure 25, control unit 49 freezes a camera frame on monitor 10.

In Step 63, control unit 49 controls X and Y table controller 17 so that the defective component to be repaired which is displayed in the camera frame is moved by X-axis table 3 and Y-axis table 4 to the highlighting location. In Step 64, the control unit directs imaging and illumination controller 47 to actuate optical highlighter 28, and the defective component is highlighted by a spotlight.

In Step 65, the operator checks the defective component which is highlighted. If he can repair it in that location, he repairs it. When the substrate is positioned for imaging, illumination unit 2 is quite close to the surface of the substrate, making it impossible to repair. When the substrate is positioned for highlighting, it is not obstructed by unit 2, so it may be possible to repair it.

If in Step 65 the substrate was repaired in the highlighting position, in Step 66 the operator inputs a command to move it to imaging position. In Step 67, control unit 49 turns off illumination unit 28, and we proceed to Step 71.

If in Step 65 the substrate was not repaired in the highlighting position, in Step 66 the operator inputs a command to move it to the repair position (the site where the substrate is loaded). In Step 68, control unit 49 turns off illumination unit 28, and in Step 69 the substrate is moved to the repair position.

In Step 70, the operator repairs the defective component. In Step 70a, he inputs a command to move the substrate to the imaging position, and we proceed to Step 71.

In Step 71, control unit 49 moves the substrate to the imaging position and the component is imaged again. In Step 72, it overlays a color picture of the component on the camera frame, and we proceed to Step 60 in Figure 24.

In Step 60, the operator checks the repaired component in the camera frame by eye and inputs whether further repairs are necessary. If he inputs "Yes," we return to Step 59; if he inputs "No," we proceed to Step 61.

In Step 61, the operator inputs the fact that the repair of this component, that is, of the first defective component in the defect file, has been completed. He then proceeds to Step 45 in Figure 21.

In Step 14, if there is another defective component, he returns to Step 41. Just as with the first defective component, the defect is repaired via the processing executed in Steps 41 through 45. This processing is repeated for every defective component.

If in Step 46 all defective components have been repaired, in Step 47 control unit 49 writes onto the floppy disk or LAN server the edited defect and image

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files, which are kept separate from those created by the inspection device. These edited files include files whose defect data have been sorted, files which have been given defect codes or flagged by the repair device when their repairs were completed, defect files in which defect codes mistakenly assigned by the inspection device have been corrected, and image files which have been corrected along with these defect files.

In Step 48, the operator inputs a command to move the substrate to the loading position and removes it from stage 5. In Step 49, he inputs whether he will repair the next substrate. If he inputs "Yes," we return to Step 38 and execute the same processing as with the previous substrate.

With the second ideal embodiment of this invention, which is described above, the data concerning defective components are sorted according to their defect codes. The operator is given directives to repair the defective components in the order resulting from the sorting. Because all components with the same type of defect are pointed out consecutively, the operator does not need to repeatedly pick up a different repair tool. The portions of the substrate which are to be repaired are highlighted with a spotlight by highlighter 28, so the operator does not need to search the substrate for the defective component. This improves the efficiency of the repair operation.

We shall next discuss a third ideal embodiment of this invention. The appearance of this third embodiment is identical to that of the first embodiment which was pictured in Figure 1, so we shall not discuss it further here.

Figure 26 shows the overall configuration of the third ideal embodiment of this invention. As can be seen in the drawing, this invention consists of imaging unit 1, illumination unit 2, X-axis table 3, Y-axis table 4, stage 5 and control processing unit 53.

Illumination unit 2 consists of a trichromatic light source composed of three annular light sources, 24, 25 and 26, each of which emits one of a red, green or blue light.

Control processing unit 53 consists of controller 16 for imaging and illumination; X and Y table controller 17; monitor 10; memory 52; floppy disk drive 12; input unit 22; bar code reader 6; network input and output unit 18; and control unit 51.

Controller 16 controls the imaging operation performed by imaging unit 1 and the emission of light by light sources 24, 25 and 26 in illumination unit 2 according to commands from control unit 51. The image signals representing the component to be repaired which are output by imaging unit 1 are converted to color video signals and transmitted to control unit 51.

X and Y table controller 17 controls the operation of X-axis table 3 and Y-axis table 4 in response to commands from control unit 51.

Monitor 10 displays the color image of the component to be repaired produced by imaging unit 1, a diagram of the layout of the substrate to be repaired and various necessary data, all of which it receives from control unit 51.

Memory 52 stores the program which operates this invention. It also stores a variety of data, including the defect files transmitted by control unit 51.

Input unit 22 has a keyboard 7, a mouse 8 and an operating keyboard 9, as shown in Figure 1. The operator can use these as needed to input various data.

Floppy disk drive 12 reads defect and image files created by the inspection device off a floppy disk in response to a command from control unit 51. It also writes onto a floppy disk defect files created by control unit 51.

Network input and output unit 18 is connected to the LAN cable 13 shown in Figure 1. In response to a command from control unit 51, it acquires from a network via LAN cable 13 defect and image files created by the inspection device. It also transmits to the network via LAN cable 13 defect files created by control unit 51.

Depending on the way in which the system which includes the inspection device is configured, either the aforesaid floppy disk drive 12 or network input and output unit 18 may be used.

Control unit 51 contains a microprocessor. According to a program which it reads out of memory 52, it controls the overall operation of the various components of control processing unit 53, creates defect data, performs various operations and reads out and edits defect files.

Figure 27 is a flowchart of the processing performed by the third ideal embodiment of this invention. Figure 28 shows the subroutines in Steps 81 and 86 in Figure 27. It is a flowchart of how the sorting conditions are set. Figure 29 is the subroutine in Step 82 in Figure 27. It is a flowchart showing the order of processing involved in reading out inspection results. Figure 30 is the subroutine in Step 89 in Figure 27. It is a flowchart giving the order of the repair operation.

In Step 81 of Figure 27, the various conditions are stipulated. More specifically, in Step 100 of the subroutine shown in Figure 28, for each defect code assigned by the inspection device (hereafter referred to as "inspection defect codes"), the type of repair to be done and the tool needed are recorded. Figure 31 shows the screen used to record the type of repair and the tool. In Figure 31, the first screen to appear is 55, the "Select Component" screen. The operator moves arrow 56 by means of keyboard 7 shown in Figure 1. He then clicks on "OK" with mouse 8 to select the component class. If he selects "R1608" as the component class, the next screen to appear will be 57, the "Designate Repair and Tool" screen. The operator records the type of repair and tool according to the inspection defect code. If "---" appears in the repair and tool column of screen 57, a type of repair and a tool have not been designated for that inspection code.

Returning to Figure 27, because a wide variety of defect codes is assigned by the inspection device, in Step 101 these codes are sorted and separate defect

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codes are assigned for the repair device (see Figure 11). For every inspection defect code, a newly assigned defect code is recorded (See Figure 12).

In Step 102, the method to be used to sort the data in the defect file is stipulated. That is, the operator inputs whether to sort the data by defect code or by type of repair. The screen shown in Figure 32 is displayed on monitor 10, which is shown in Figure 1. The operator sets the sorting method by clicking on input window 58 with mouse 8 shown in Figure 1. In Figure 32, if he clicks on "Yes" in input window 29, it will change to "No." The sorting conditions, i.e., whether to sort the data by defect code or by type of repair, are also interlocked. If the operator clicks on "Yes" for "Sort Data by Type of Repair," it will change to "No," and "Sort Data by Defect Code" will change to "Yes." When he has completed setting the conditions, the operator clicks on "OK."

If sorting by type of repair was chosen in Step 102, the order in which the types of repairs are to be sorted is recorded in Step 103. Returning to Figure 27, we proceed to Step 82. Figure 33 shows the screen used to set the order in which the data are to be sorted by type of repair. In this figure, the defect data for components which need the repair "apply solder" are sorted first, and those for components which need the repair "cut bridge" are sorted next. Defect data for components requiring the same repair will be sorted in increasing order by part number. In other words, they will be arranged in the same order in which they were inspected.

If sorting by defect code was chosen in Step 102, in Step 104, the order in which the defect codes will be sorted is recorded (See Figure 13). We return to Figure 27 and proceed to Step 82.

In Step 82, the defect and image files showing the results of the inspection are read out. That is, in Step 105 of the subroutine shown in Figure 29, the operator inputs the ID number of the substrate to be repaired using either bar code reader 6 or keyboard 7, both of which are pictured in Figure 1. In Step 106, control unit 51 reads off the floppy disk or LAN server the defect and image files for the ID number which was input. We return to Figure 27 and proceed to Step 83.

In Step 83, control unit 51 sorts the data in the defect file according to the conditions stipulated in Step 81. In Step 84, the operator places the substrate to be repaired on stage 5, shown in Figure 1.

In Step 85, if the sorting conditions stipulated in Step 81 are not to be modified, the operator inputs "No," and we proceed to Step 88. If the operator wishes to modify the conditions, he inputs "Yes," and he stipulates new conditions in Step 86. In Step 87, the defect data are resorted according to the new conditions, and we proceed to Step 88. The processing in Step 86 is the same as that in Step 81, and that in Step 87 is the same as that in Step 83. If from Step 90, which will be discussed hereafter, we proceed to the processing in Step 87 by way of Steps 85 and 86, the components which have already been repaired will be eliminated from the data to be sorted.

In Step 88, control unit 51 moves X-axis table 3 and Y-axis table 4 until the first defective component from the defect file which was sorted is in the imaging position shown in Figure 18 (b), directly below imaging unit 1. The defect data for this component, which consist of the color image of the defective component captured by imaging unit 1, the defect code for this component and a diagram showing the layout of components on the substrate which was created from data in the image file (See Figure 14), are all displayed on monitor 10.

Figure 34 is the screen displaying the defect data in Step 88 of Figure 27. In the same figure, 39 is the camera frame displaying the color video image of the defective component which was captured by imaging unit 1. 40 is a layout screen which uses the layout diagram to indicate where the component displayed in the camera frame is located on the substrate. The component displayed in the camera frame is distinguished from the other defective components (by being colored or by an arrow, for example). 41 is the identification code for the defective component displayed in the camera frame, and 42 is the defect which corresponds to the defect code for that component. 59 is the repair which this component needs. 60 is the tool needed to repair this component. 43 is the command menu, which can be started as needed to perform the repair in Step 89 of Figure 27.

Returning to Figure 27, in Step 89, the operator repairs the defect while viewing the screen displaying the defect data. That is, in Step 110 of the subroutine shown in Figure 29, the operator views the camera frame on monitor 10 to check the condition of the defect. In Step 111, if he determines that the defect data displayed on monitor 10 are correct, we proceed to Step 112. If he determines that the data are wrong or that the location of the defect does not exist, in Step 113 he changes or cancels the inspection defect code, the description of the repair needed, or the tool to be used, and we proceed to Step 113.

In Step 113, the operator inputs whether he will repair this component. If he will not, we proceed to Step 123. If he will, we proceed to Step 114.

In Step 114 the operator inputs an order to move the substrate to the repair position (the loading and unloading position) shown in Figure 18 (a). In Step 115, control unit 51 freezes a camera frame on monitor 10. In Step 116, the substrate is moved to the repair position.

In Step 117 the operator consults the layout diagram shown on monitor 10, finds the defective component and repairs it. In Step 118 he inputs a command to move the substrate to the position shown in Figure 18. In Step 119 control unit 51 moves the substrate to the imaging position and images the component again. In Step 120 a color image of the component is overlaid on the camera frame.

In Step 121, the operator checks the repaired component in the camera frame by eye, and in Step 122, he inputs whether further repairs are necessary. If he

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inputs "Yes," we repeat steps 114 through 121; if he inputs "No," we proceed to Step 123.

In Step 123, the operator inputs the fact that the repair of this component, that is, of the first defective component in the defect file, has been completed. We then proceed to Step 90 in Figure 27.

In Step 90, if there is another defective component, we return to Step 85. Just as with the first defective component, we repeat the processing in Steps 85 through 89. If in Step 90 all defective components have been repaired, in Step 91 control unit 51 writes onto the floppy disk or LAN server the edited defect and image files, which are separate from those in the inspection device. These edited files include files whose defect data have been sorted, files which have been given defect codes and descriptions of repairs and tools needed by the repair device or flagged when their repairs were completed, defect files in which defect codes mistakenly assigned by the inspection device have been corrected, and image files which have been corrected along with these defect files.

In Step 92, the operator inputs a command to move the substrate to the loading position and removes it from stage 5. In Step 93, he inputs whether he will repair the next substrate. If he inputs "Yes," we return to Step 82 and execute the same processing as with the previous substrate.

With the third embodiment described above, then, the defect data are sorted according to type of repair needed. The operator is given directives to repair the defective components in the order resulting from the sorting. Because all components requiring the same type of repair are pointed out consecutively, the operator does not need to repeatedly pick up a different repair tool. Because the type of repair and the tool needed are indicated to the operator when he is about to make the repair, even an operator who lacks repair experience will never use the wrong tool or hesitate in choosing a tool. This improves the efficiency of the repair operation.

We shall next discuss a fourth ideal embodiment of this invention. Because the appearance of this embodiment is identical to that of the first embodiment, which was shown in Figure 1, we shall not discuss it further at this point.

A drawing of the overall configuration of this fourth embodiment would be identical to that of the first embodiment shown in Figure 2, with the following exceptions. Control unit 23 would be replaced by control unit 71; memory 15 would be replaced by memory 72; and control processing unit 27 would be replaced by control processing unit 73. In other words, the configuration of this embodiment is identical to that of the first embodiment with the exception of the control unit and the memory.

Memory 72 stores the program which runs this invention. It also stores various data such as the defect files for a number of substrates which are transmitted by control unit 71.

Control unit 71 contains a microprocessor. According to the program which it reads out of memory 72, it controls the overall operation of the various components of control processing unit 73, creates data concerning required repair time, performs various calculations and reads out and edits the defect files for a number of substrates.

Figure 35 is a flowchart of the processing performed by the fourth ideal embodiment of this invention to produce repair times. Figure 36 shows the subroutine in Step 134 of Figure 35. It is a flowchart of the readout of one batch of inspection results. Figure 37 is the subroutine in Step 140 in Figure 35. It is a flowchart of the repair operation.

In Step 131 of Figure 35 the inspection defect codes are sorted, and independent defect codes are set for the repair device (See Figure 11). For each defect code assigned by the inspection device, the new defect code which has been assigned is recorded (See Figure 12).

In Step 132, a repair time is recorded for every defect code assigned in Step 131. The repair time for a defect code is the time required to repair the defective component to which that code is assigned.

In Step 133, a limit is set for the total time which would be required to repair every defective component on a single substrate. This limit value is determined in consideration of economy of cost. It might be determined, for example, by finding the value for total repair time where it stops being cost-effective to repair a substrate.

Figure 38 shows the screen used to set the repair time for each defect code in Step 132 and the limit for total repair time in Step 133.

Returning to Figure 35, in Step 134 the defect and image files created during the inspection are read out for every substrate to be repaired. In Step 151 of the subroutine shown in Figure 36, the operator inputs the ID numbers of all the substrates to be repaired using either the bar code reader 6 or the keyboard 7 pictured in Figure 1. In Step 152, control unit 71 reads off the floppy disk or LAN server the entire set of defect and image files for all the ID numbers which have been input and stores them in memory 72.

Returning to Figure 35, in Step 135 control unit 71 calculates the total repair time for each substrate.

In Step 136, the substrates are sorted in increasing or decreasing order of repair times. In Step 137, substrates whose repair time exceeds the limit are extracted.

In Step 138, the total repair time data are displayed on monitor 10. Either the identification codes for the substrates or their ID numbers are displayed, along with the total repair time, in the order into which they were sorted. Substrates whose total repair time exceeds the limit are marked with a special symbol. Figure 39 is the screen which displays the total repair time data. In this figure the substrates have been sorted in increasing order of repair time. Triangles 75 are the symbols used

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to mark substrates whose projected repairs exceed the time limit. Column 76 indicates whether the repair has been completed. An asterisk indicates that the substrate has already been repaired when Step 138 has been reached by branching from Step 141, which will be discussed at a later point. A dash indicates that the substrate has not yet been repaired.

In Step 139, the operator views the screen displaying the aforesaid repair time data and selects the substrate he will repair next.

In Step 140, the operator repairs the substrate he has selected. That is, in Step 153 of Figure 37, the operator enters the ID number of the substrate he has selected.

In Step 154, control unit 71 checks whether the repair time for this substrate is within the limit value. If due to operator error or some other cause this substrate exceeds the limit, in Step 155 an error message will be displayed and the substrate will not be repaired.

If in Step 154 the total repair time is found to be within the limit value, in Step 155 the operator places the substrate which he has selected on stage 5, shown in Figure 1.

In Step 156, the operator stipulates the conditions under which the data in the defect file are to be sorted. Since the order of sorting must be recorded before the operator can repair the first substrate, he must input "Yes" at this time. In Step 157 the defect codes are recorded just as in Step 131 (See Figure 12). In Step 158 the order in which the data have been sorted by defect code is recorded (See Figure 13). In Step 159, control unit 71 sorts the data in the defect file according to the conditions stipulated in Steps 157 and 158, and we proceed to Step 160. If the defect codes set in Step 131 do not need to be modified, there is no need to record new defect codes in Step 157.

When several substrates have been repaired or when there is no need to modify the sorting conditions after branching from Step 162, which will be discussed later, the operator inputs "No" in Step 156, and we proceed to Step 160.

In Step 160, control unit 71 displays the data for the defective component on monitor 10 (See Figure 15).

In Step 161, the component is repaired using the same order of processing as in the first embodiment, shown in Figure 9.

In Step 162, if there is another defective component, we return to Step 156. Just as with the first defective component, we repeat the processing in Steps 157 through 161. If in step 162 all defective components have been repaired, in Step 163 control unit 71 writes onto the floppy disk or LAN server the edited defect and image files, keeping them separate from those created by the inspection device. These edited files include files whose defect data have been sorted, files which have been given defect codes by the repair device or flagged when their repairs were completed, defect files in which defect codes mistakenly assigned by the inspection device have been corrected (see Figure 16 (c)), and image files which have been corrected along with these defect files.

In Step 164, the operator inputs a command to move the substrate to the loading position and removes it from stage 5. We proceed to Step 141 in Figure 35.

In Step 141, he inputs whether he will repair another substrate. If he inputs "Yes," we return to Step 138, and the operator views the total repair time data displayed on monitor 10. He selects a substrate from the group of substrates whose repair times are within the limit and which have not yet been repaired. In Step 140 he repairs this substrate.

Here the defect data have been sorted by defect code. It would be equally acceptable to sort the data by type of repair as in the third embodiment.

The repair processing in Step 161 of Figure 37 could also be performed using an optical highlighter as in the second embodiment.

With the fourth ideal embodiment described above, then, the defect files for a number of substrates are read out in a batch. A repair time is stipulated for each defect code and the total repair time is calculated for each substrate. The total repair times are displayed along with the identification codes for the substrates in increasing or decreasing order. Substrates whose total repair times exceed a previously stipulated limit are flagged and removed from the batch to be repaired. This method allows the repair of substrates to be accomplished more cost-effectively.

As can be seen from the ideal embodiments described above, with the method and device to support in the repair of substrates according to this invention, the data concerning defective components are sorted according to defect code or type of repair needed. The operator is given directives to repair the defective components in the order into which the data have been sorted. Because the same types of defects are indicated consecutively, the operator does not need to repeatedly pick up a different repair tool. The effect which is achieved is that the repair operation is executed more efficiently.

In addition, with the method described in Claim 4 of this application and the device described in Claim 15, the portion of the substrate which must be repaired is highlighted with a spotlight. The operator does not need to search the substrate for the defective component. This achieves the effect of improving the efficiency of the repair operation.

Further, with the method described in Claim 5 of this application and the device described in Claim 16, the type of repair and the tool needed to repair the defect are indicated to the operator, so even an operator who lacks repair experience will never use the wrong tool or hesitate in choosing a tool. This achieves the effect of improving the efficiency of the repair operation.

In addition, with the method described in Claim 11 of this application and the device described in Claim 23, the defect data for a number of substrates are read out in a batch. A repair time is stipulated for each defect

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code and the total repair time is calculated for each substrate. Codes identifying the substrates are displayed in the order of their total repair times. Substrates whose total repair times exceed a previously stipulated limit are flagged and removed from the batch to be repaired. This method achieves the effect of making the repair of substrates more cost-effective.

Claims

1. A method to support in a work of repairing defective portions of a substrate on which components are mounted when said defective portions have been discovered during an inspection process, comprising:

   a recording process to record a defective data associated with said defective portions in said inspection process;

   a data sorting process, by means of a sorting device, to sort said defective data so as to group together said defective data associated with a same type of defect; and

   a data indicating process, by means of a highlighting device, to indicate a defective location on said substrate where said defective portions were found, in an order determined by said defective data associated with said same type of defect in said data sorting process.

2. A method to support in a work of repairing a defective portion of a substrate according to claim 1, wherein said data indicating process, by means of a highlighting device, indicates said defective location on said substrate, in an order determined by said defective data associated with defects requiring same type of repair.

3. A method to support in a work of repairing defective portions of a substrate according to claim 1, wherein said data indicating process highlights said defective location by projecting a spotlight by a positioning device.

4. A method to support in a work of repairing a defective portion of a substrate according to claim 2, wherein said data indicating process, by means of a highlighting device, further indicates said repair required and tools to be used.

5. A method to support in a work of repairing a defective portion of a substrate according to claim 1, further comprising an imaging process to image and display said defective location in which, after said data sorting process has been completed, a positioning device moves said substrate so that said defective location is in a position where it can be highlighted.

6. A method to support in a work of repairing defective portions of a substrate on which components are mounted when said portions have been discovered during an inspection process, comprising:

   a recording process to record a defective data associated with said defective portions in said inspection process;

   an evaluation process to calculate a total repairing time for said defective portions, and to issue a warning if said repairing time exceeds a predetermined time limit.

7. A method to support in a work of repairing defective portions of a substrate on which components are mounted when said portions have been discovered during an inspection process, comprising:

   a recording process to record a defective data associated with said defective portions in said inspection process; and

   a data sorting process to sort said defective data in an order of a total repair time of said substrate, beginning with the shortest repair time required.

8. A device to support in a work of repairing defective portions of a substrate on which components are mounted when said defective portions have been discovered during an inspection process, comprising:

   a recording device to record a defective data associated with said defective portions in said inspection process;

   a data sorting device to sort said defective data so as to group together said defective data associated with a same type of defect; and

   a data indicating device, by means of a highlighting device, to indicate a defective location on said substrate where said defective portions were found, in an order determined by said defective data associated with said same type of defect in said data sorting device.

9. A device to support in a work of repairing a defective portion of a substrate according to claim 8, wherein said data indicating device indicates said defective location on said substrate, in an order determined by said defective data associated with defects requiring same type of repair.

10. A device to support in a work of repairing a defective portion of a substrate according to claim 8, wherein said data indicating device indicates said defective location on a video display.

11. A device to support in a work of repairing a defective portion of a substrate according to claim 8, wherein said data indicating device comprises a positioning device to indicate a position of defective portion by projecting a spotlight.

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12. A device to support in a work of repairing a defective portion of a substrate according to claim 9, wherein said data indicating device further indicates said repair required and tools to be used.

13. A device to support in a work of repairing a defective portion of a substrate according to claim 12, wherein said data indicating device indicates said indications on a video display.

14. A device to support in a work of repairing a defective portion of a substrate according to claim 11, wherein said data indicating device indicates said repair required and tools to be used.

15. A device to support in a work of repairing a defective portion of a substrate according to claim 8, wherein said data indicating device, comprising:

an imaging device to image and display said sorted defective portion; and

a positioning device to determine a location of said sorted defective portion to image by said imaging device.

16. A device to support in a work of repairing a defective portion of a substrate according to claim 11, wherein said data indicating device, comprising:

an imaging device to image and display said sorted defective portion; and

a positioning device to determine a location of said sorted defective portion to image by said imaging device.

17. A device to support in a work of repairing defective portions of a substrate on which components are mounted when said portions have been discovered during an inspection process, comprising:

a recording device to record a defective data associated with said defective portions in said inspection process;

an evaluation device to calculate a total repairing time for said defective portions, and to issue a warning if said repairing time exceeds a predetermined time limit.

18. A device to support in a work of repairing defective portions of a substrate on which components are mounted when said portions have been discovered during an inspection process, comprising:

a recording device to record a defective data associated with said defective portions in said inspection process; and

a data sorting device to sort said defective data in an order of a total repair time of said substrate, beginning with the shortest repair time required.

19. A device to support in a work of repairing defective portions of a plurality of substrate on which components are mounted when said portions have been discovered during an inspection process, comprising:

a recording device to record a defective data of said plurality of substrate associated with said defective portions in said inspection process;

a data sorting device to sort said defective data in an order of a total repair time of said substrate, beginning with the shortest repair time required; and

an evaluation device to calculate a total repairing time for said sorted defective portions, and to issue a warning if said repairing time exceeds a predetermined time limit.

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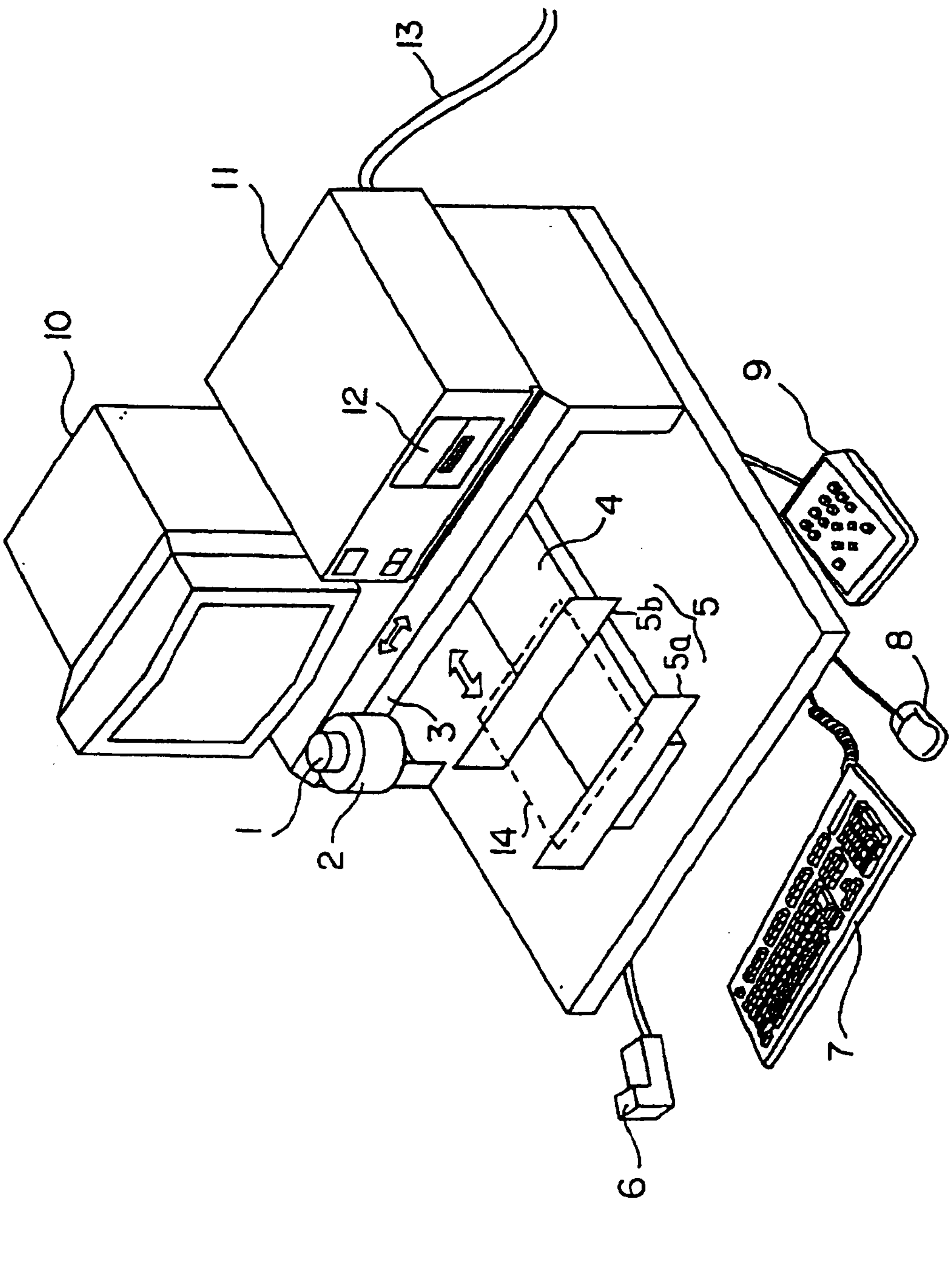
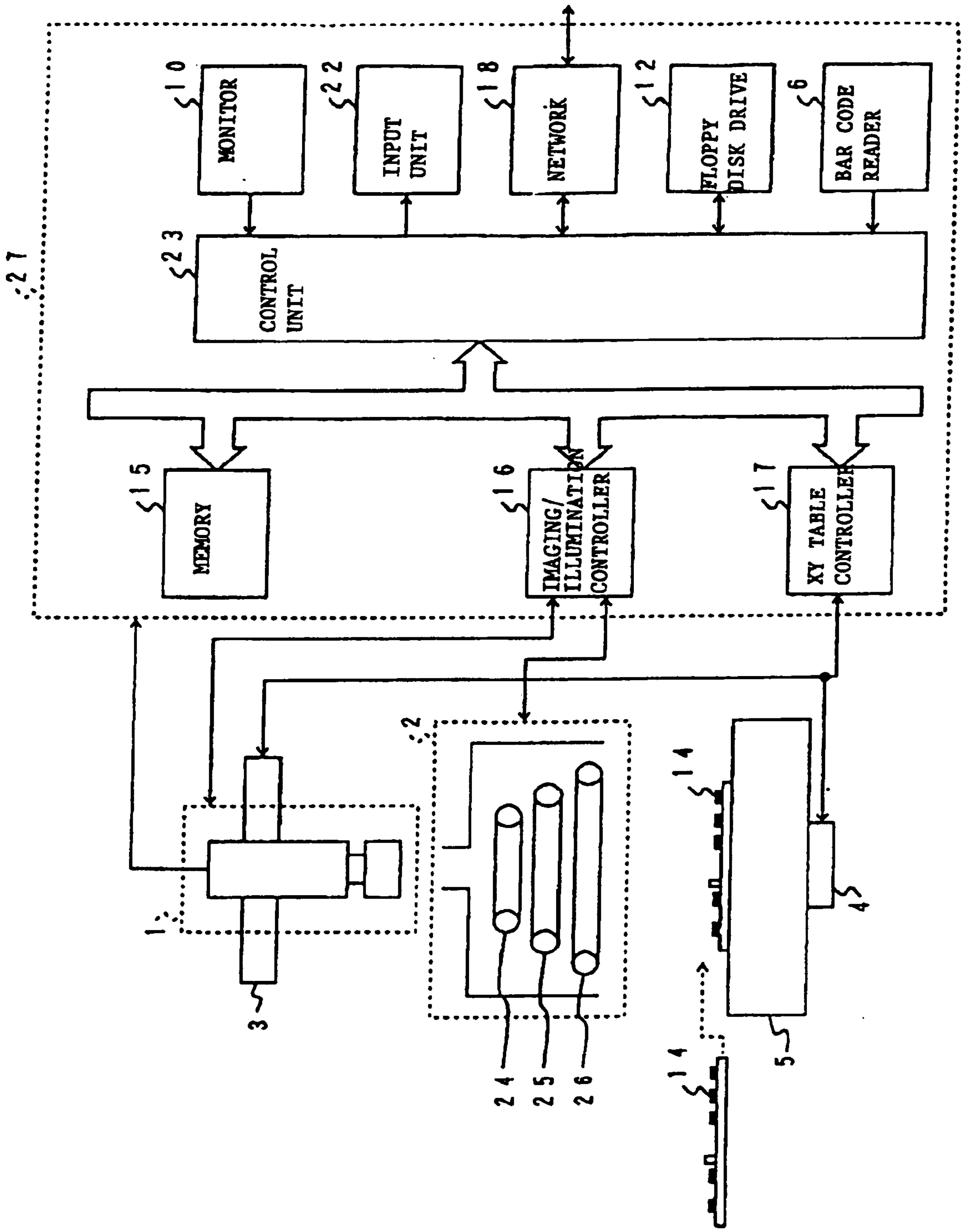
FIGURE 1



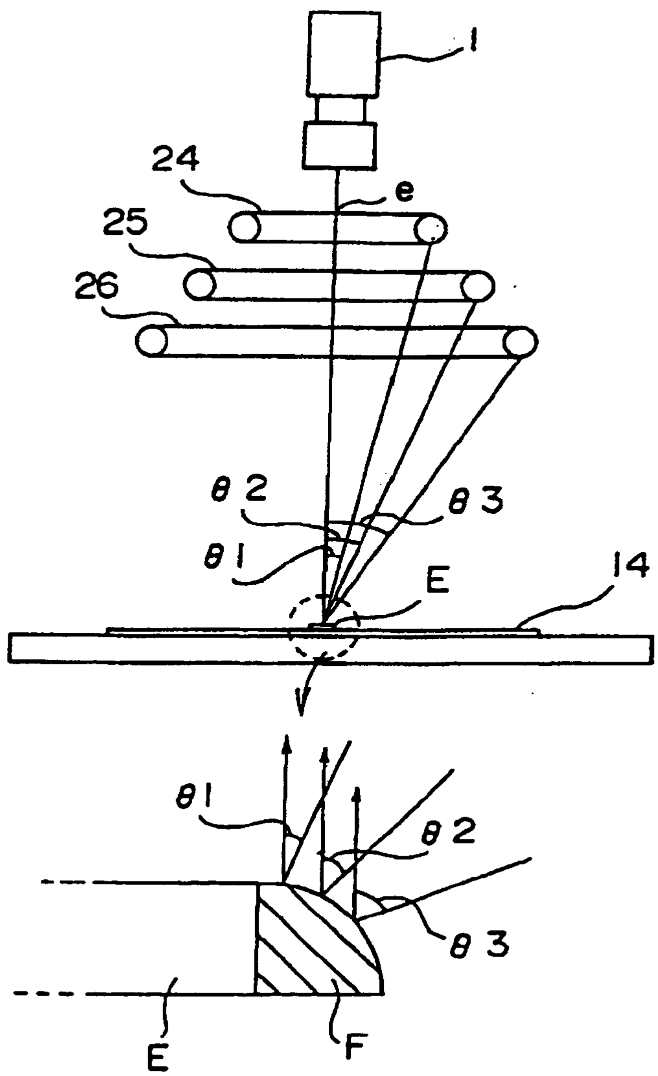
NSDOCID: <EP___0723390A2_I_>

FIGURE 2



BNSDOCID: <EP___0723390A2_I_>

FIGURE 3



NSDOCID: <EP___0723390A2_I_>

FIGURE 4

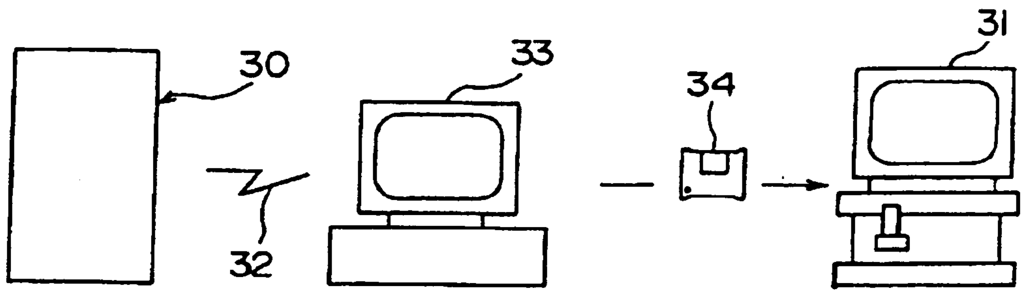
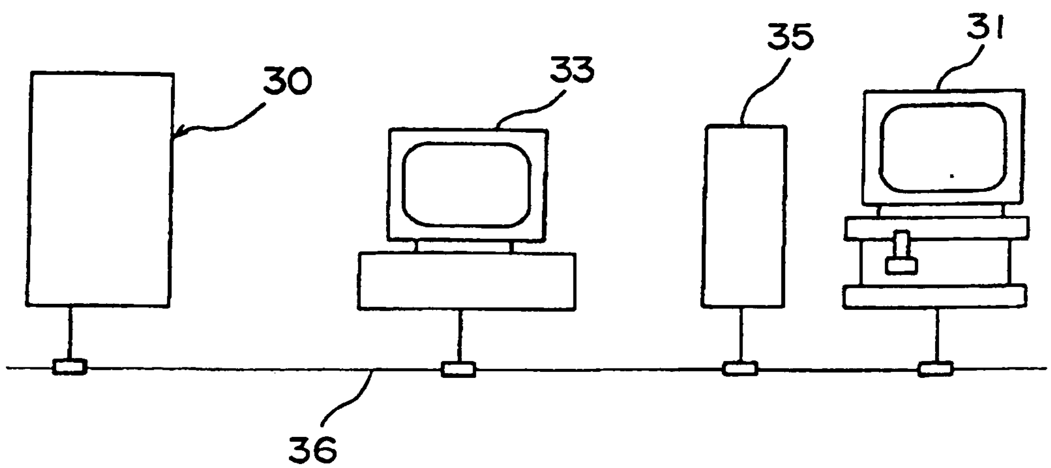


FIGURE 5



BNSDOCID: <EP___0723390A2_I_>

FIGURE 6

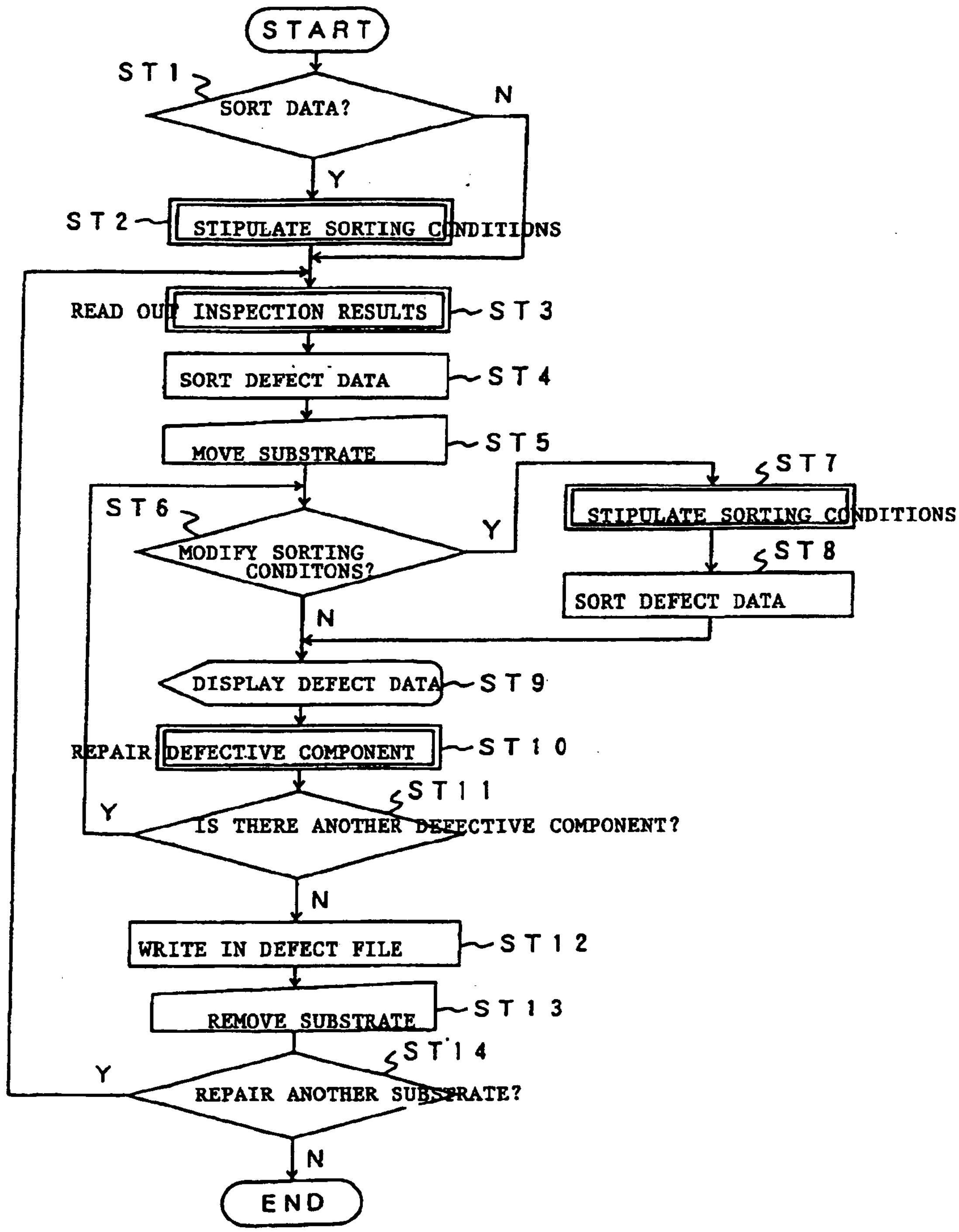


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FIGURE 7

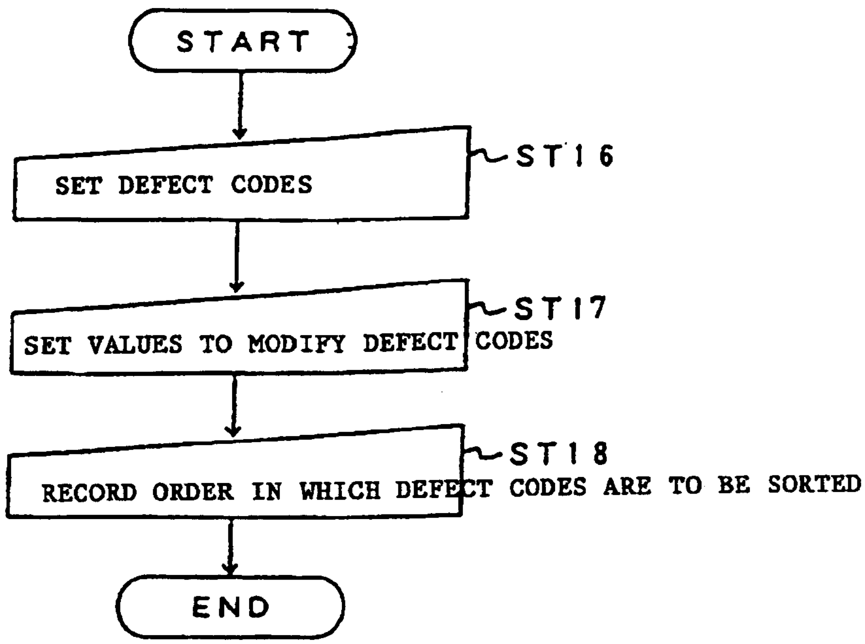
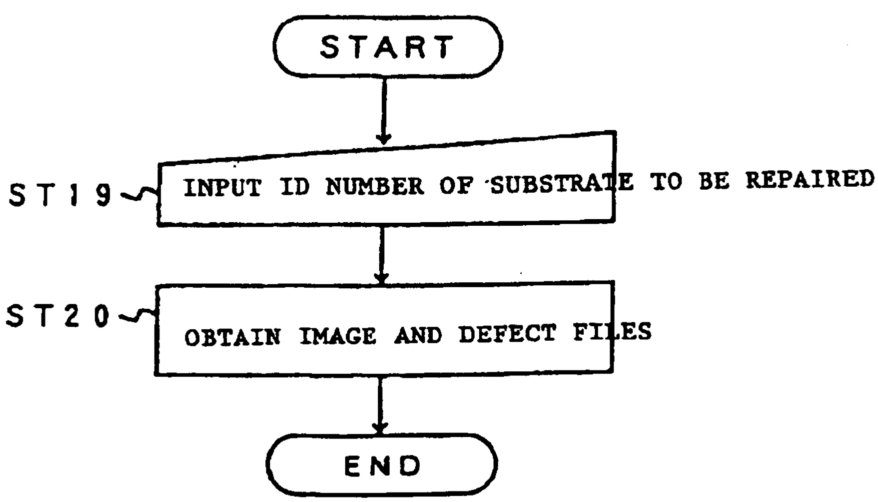
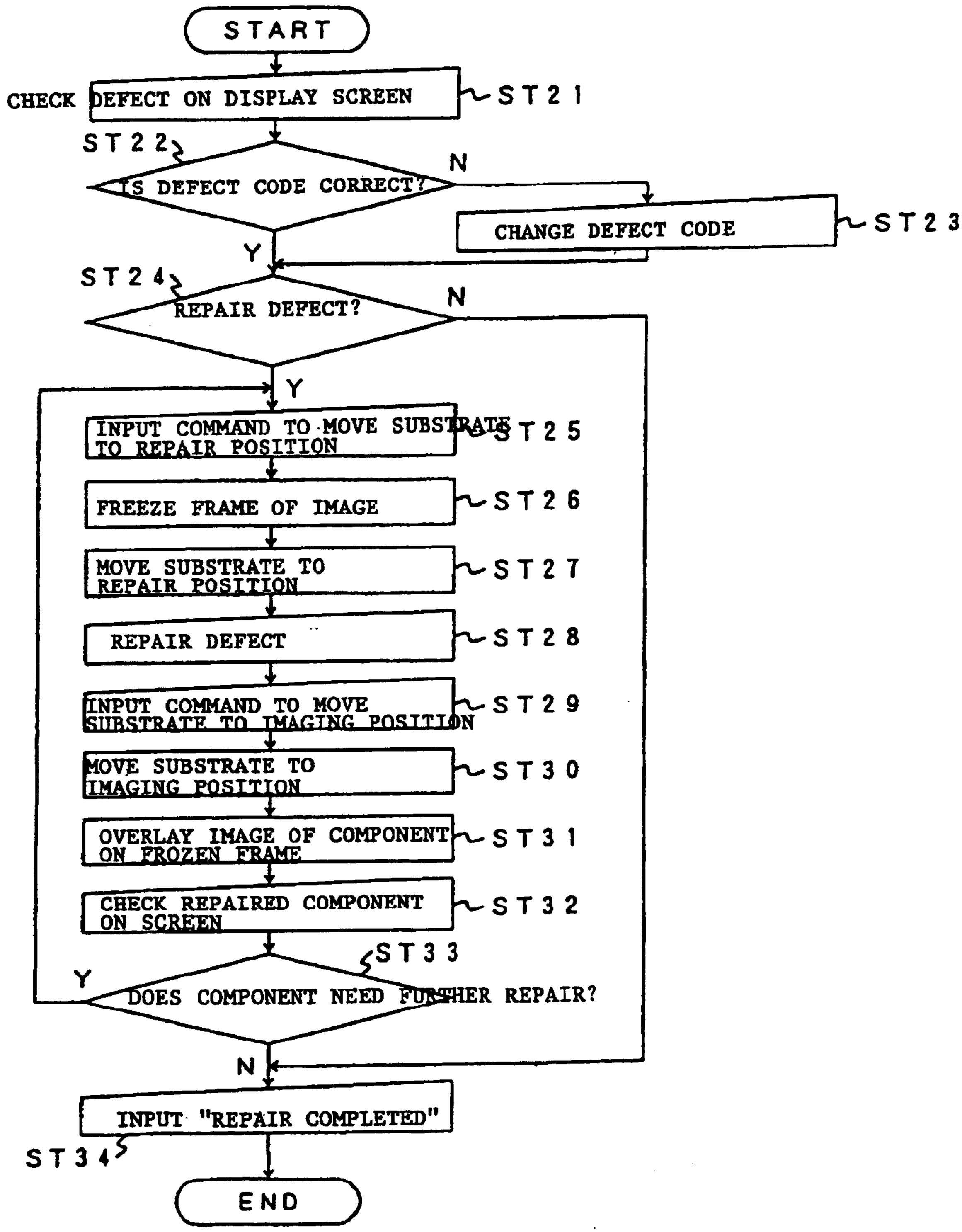


FIGURE 8



NSDOCID: <EP___0723390A2_I_>

FIGURE 9



INSDOCID: <EP___0723390A2_I_>

FIGURE 10

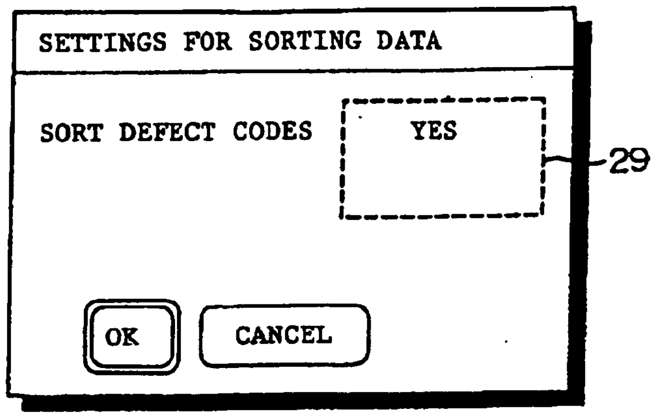
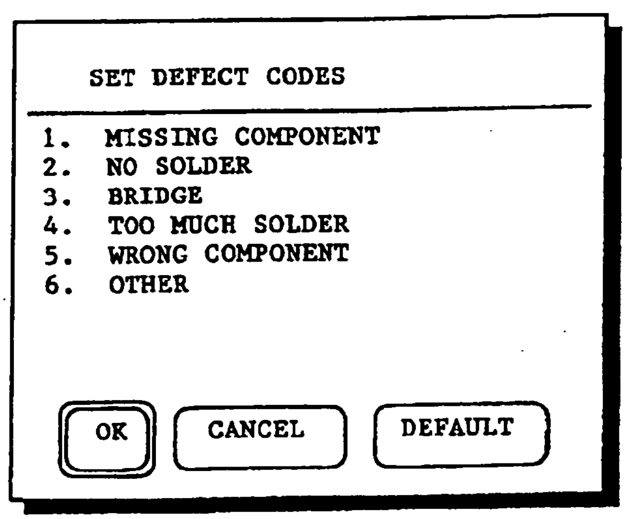


FIGURE 11



BNSDOCID: <EP___0723390A2_I_>

FIGURE 12

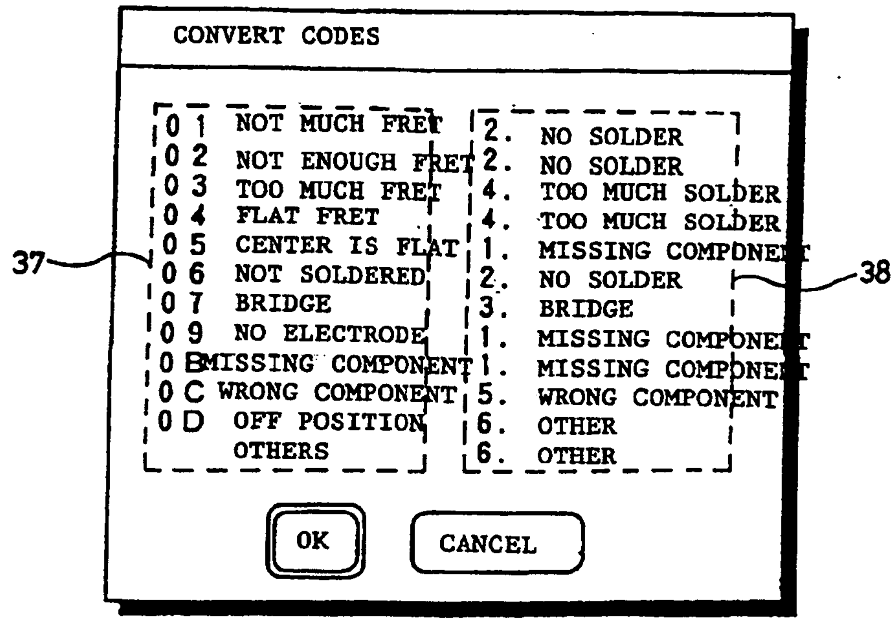


FIGURE 13

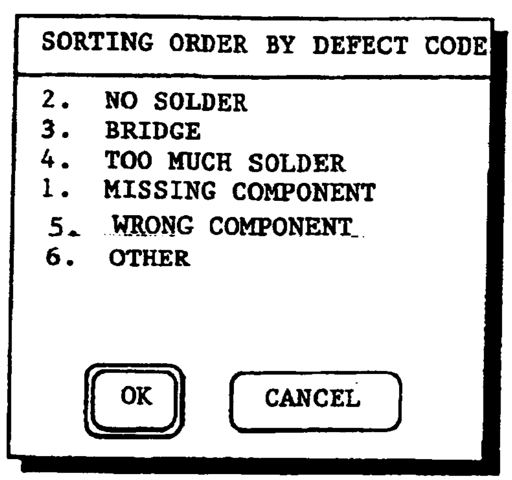


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FIGURE 14

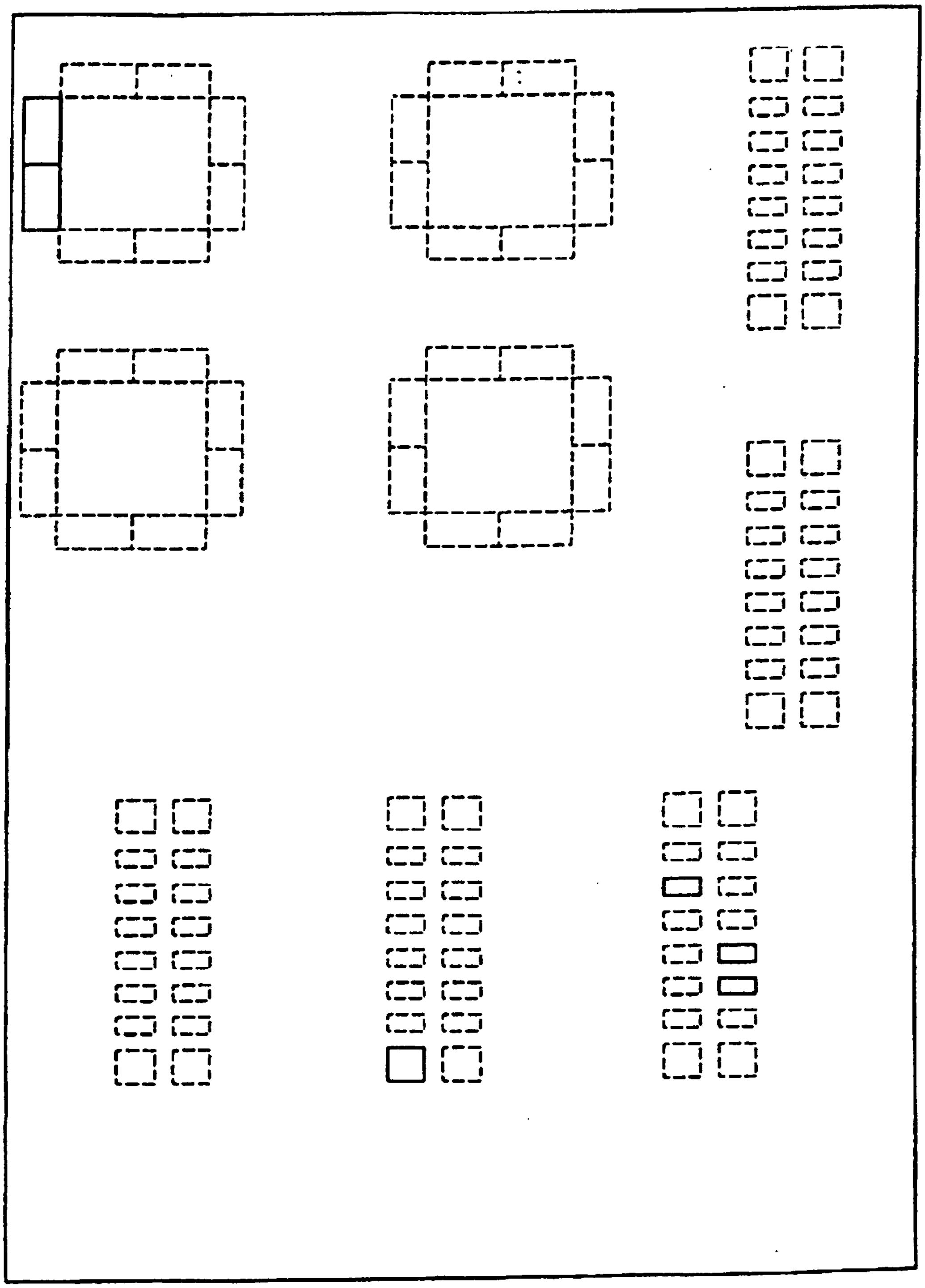

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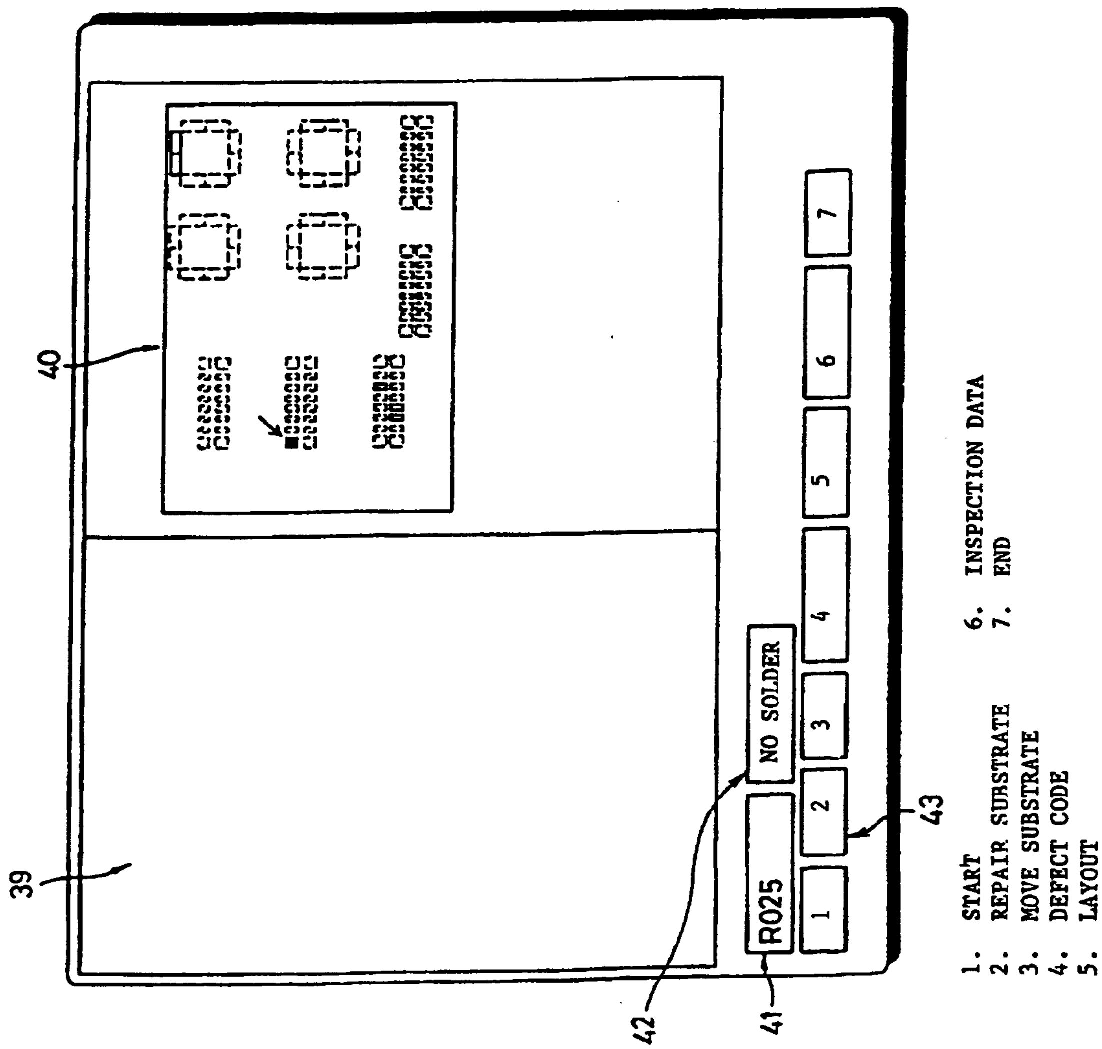
FIGURE 15



NSDOCID: <EP___0723390A2_I_>

FIGURE 16

(a)

PART NUMBER	ID NUMBER	TYPE OF PART	X COOR-DINATE	Y COOR-DINATE	DEFECT CODE
0035	R024	R1608	090000	050000	07
0036	R025	R1608	093000	050000	01
0038	C008	C2125	120000	055000	0D
0052	TR1	TR3P	070000	120000	07
0103	IC3-22	0.80FP	320000	250000	0B
0104	IC3-30	0.80FP	326000	250000	0A
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.	.	.	.	.	.

(b)

PART NUMBER	ID NUMBER	TYPE OF PART	X COOR-DINATE	Y COOR-DINATE	DEFECT CODE	CONVERTED DEFECT CODE
0036	R025	R1608	093000	050000	01	2. NO SOLDER
0035	R024	R1608	090000	050000	07	3. BRIDGE
0052	TR1	TR3P	070000	120000	07	3. BRIDGE
0103	IC3-22	0.80FP	320000	250000	0B	1. MISSING COMPONENT
0038	C008	C2125	120000	055000	0D	6. OTHER
0104	IC3-30	0.80FP	326000	250000	0A	6. OTHER
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.	.	.	.	.	.	.
.	.	.	.	.	.	.

(c)

PART NUMBER	ID NUMBER	TYPE OF PART	X COOR-DINATE	Y COOR-DINATE	DEFECT CODE	CONVERTED DEFECT CODE	
0036	R025	R1608	093000	050000	05	2. NO SOLDER	*
0035	R024	R1608	090000	050000	01	3. BRIDGE	*
0052	TR1	TR3P	070000	120000	02	3. BRIDGE	*
0103	IC3-22	0.80FP	320000	250000	07	1. MISSING COMPONENT	
0038	C008	C2125	120000	055000	04	6. OTHER	—
0104	IC3-30	0.80FP	326000	250000	0A	6. OTHER	—
.	.	.	.	.	.	.	.
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BNSDOCID: <EP___0723390A2_I_>

FIGURE 17

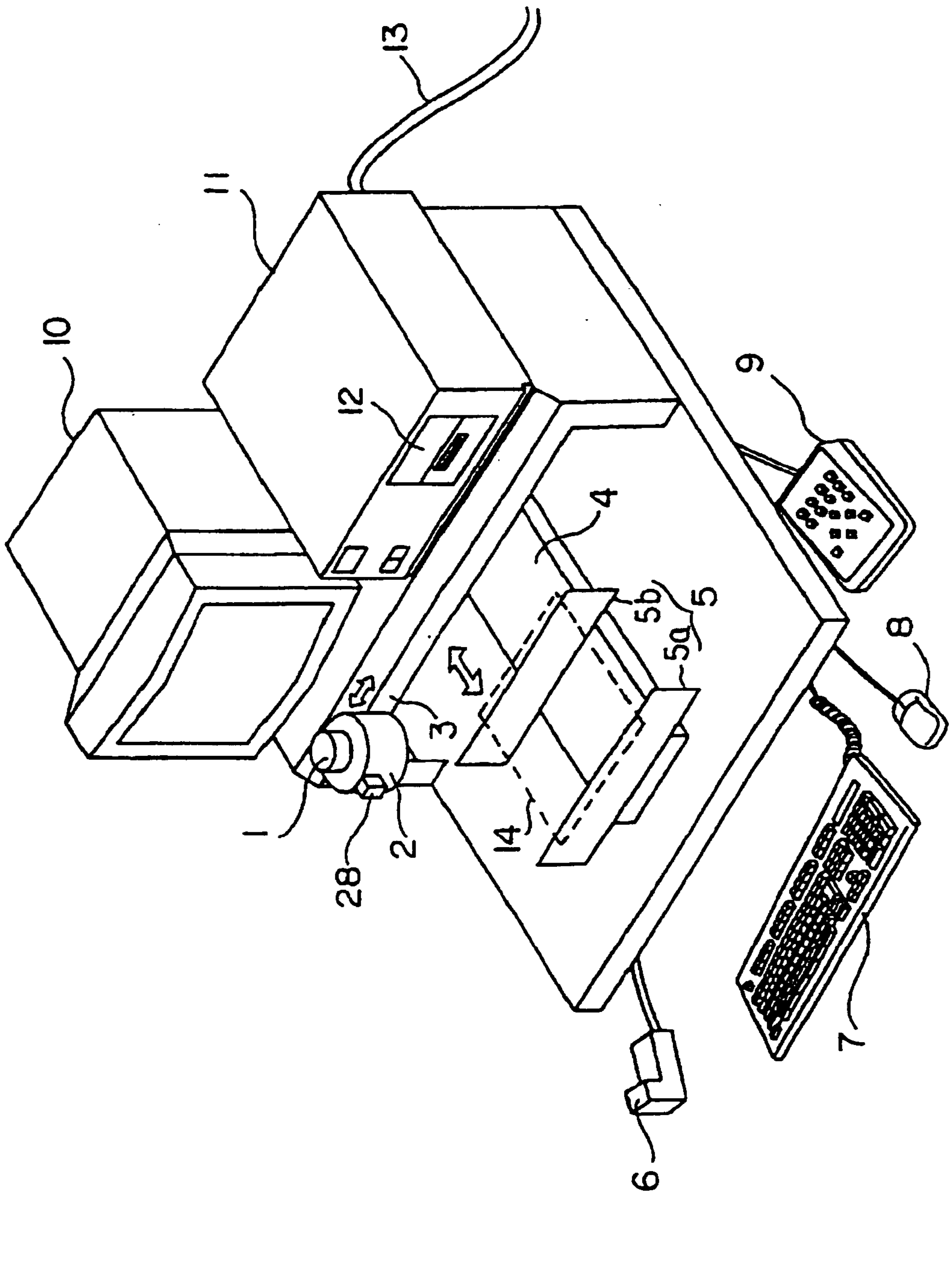

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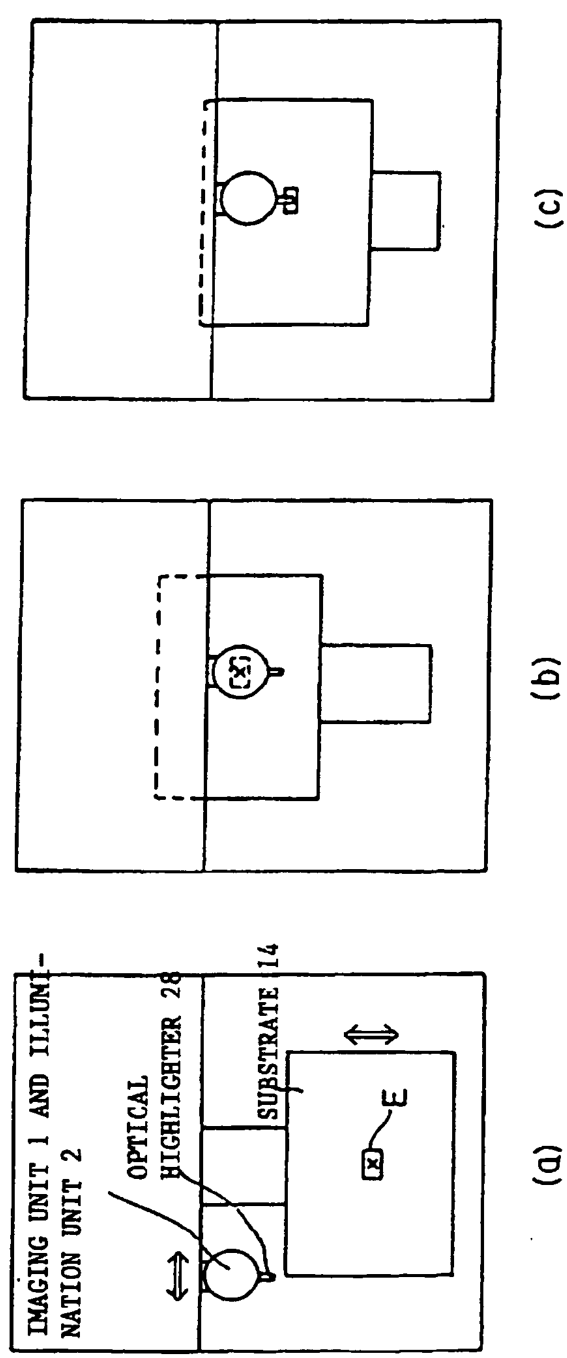
FIGURE 18



BNSDOCID: <EP___0723390A2_I_>

FIGURE 19

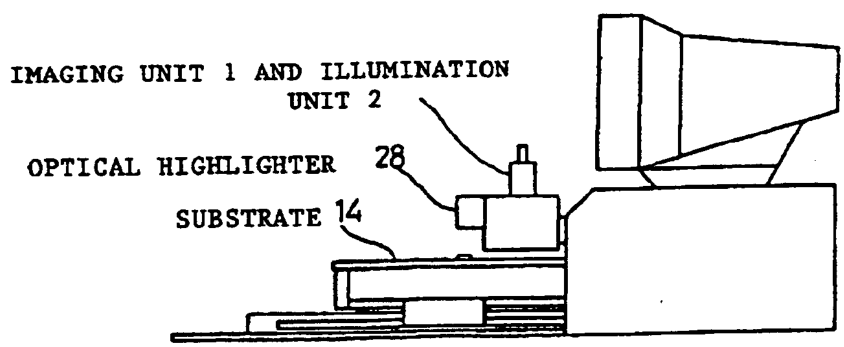


FIGURE 20

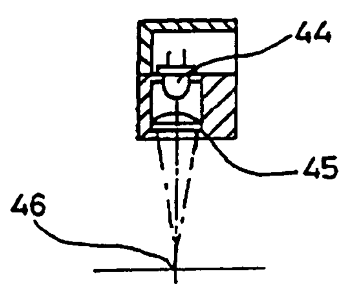


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FIGURE 21

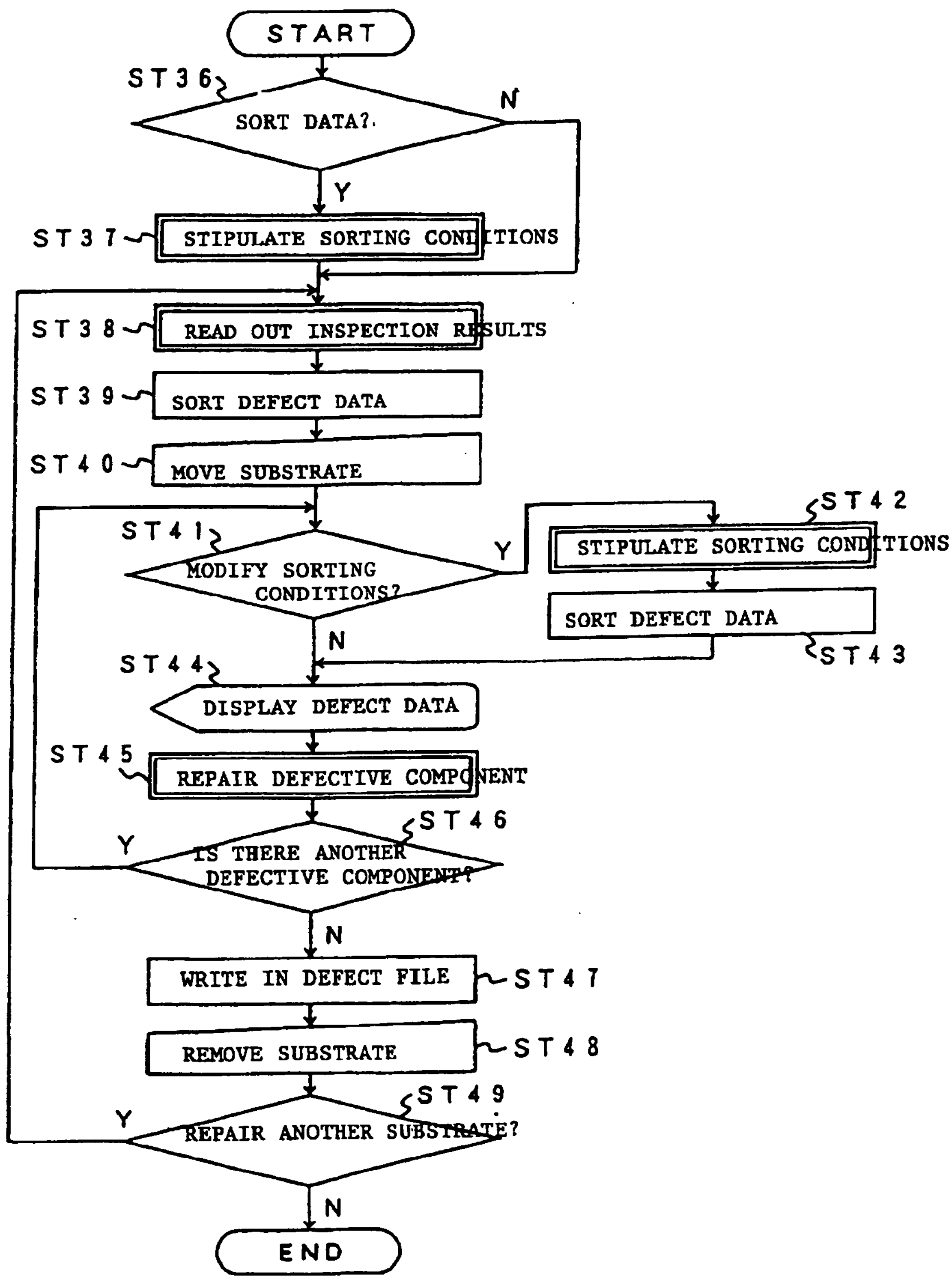

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FIGURE 22

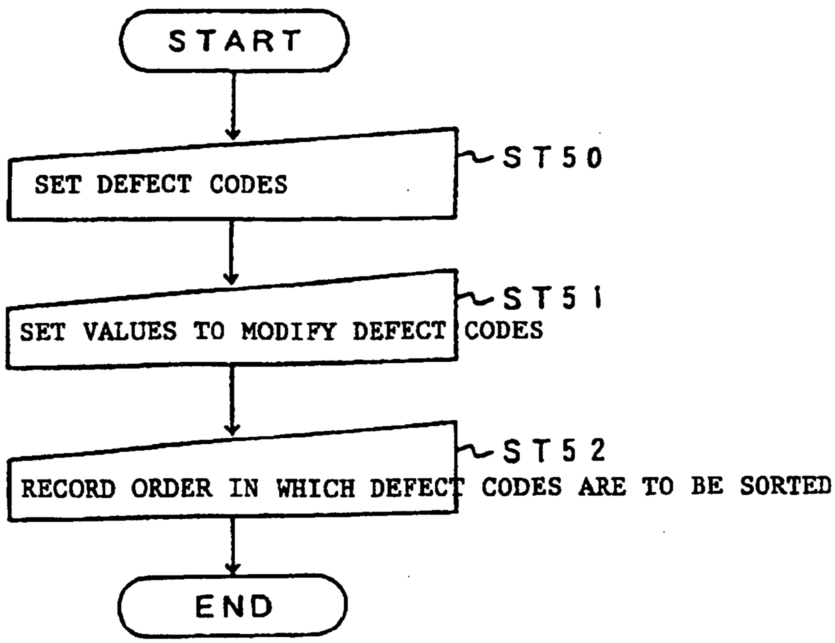

FIGURE 23

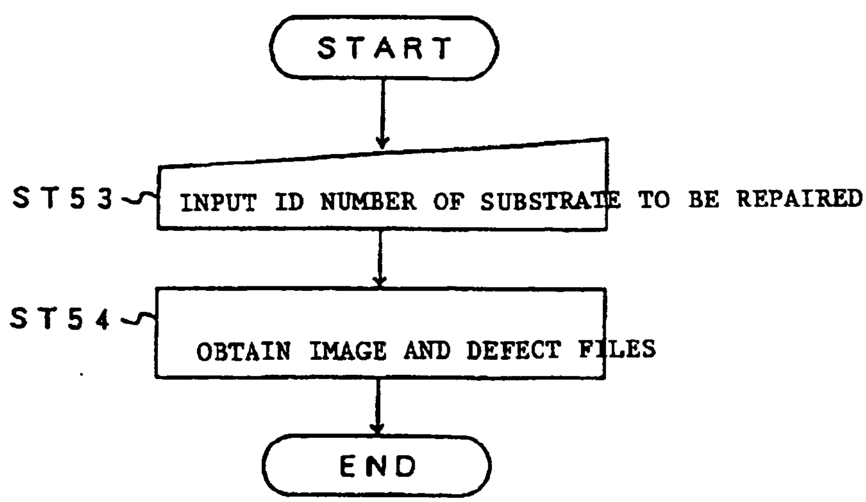

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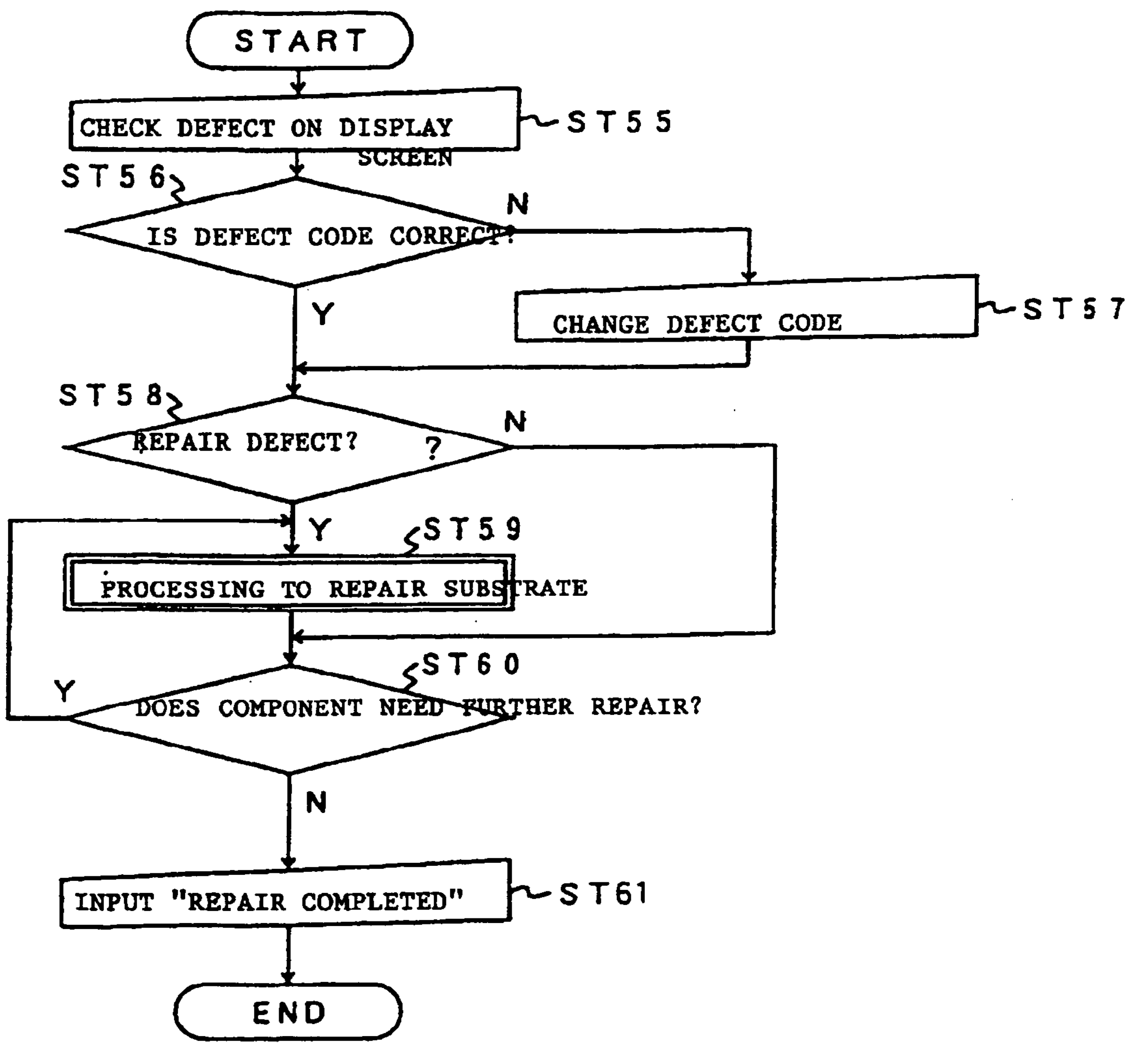
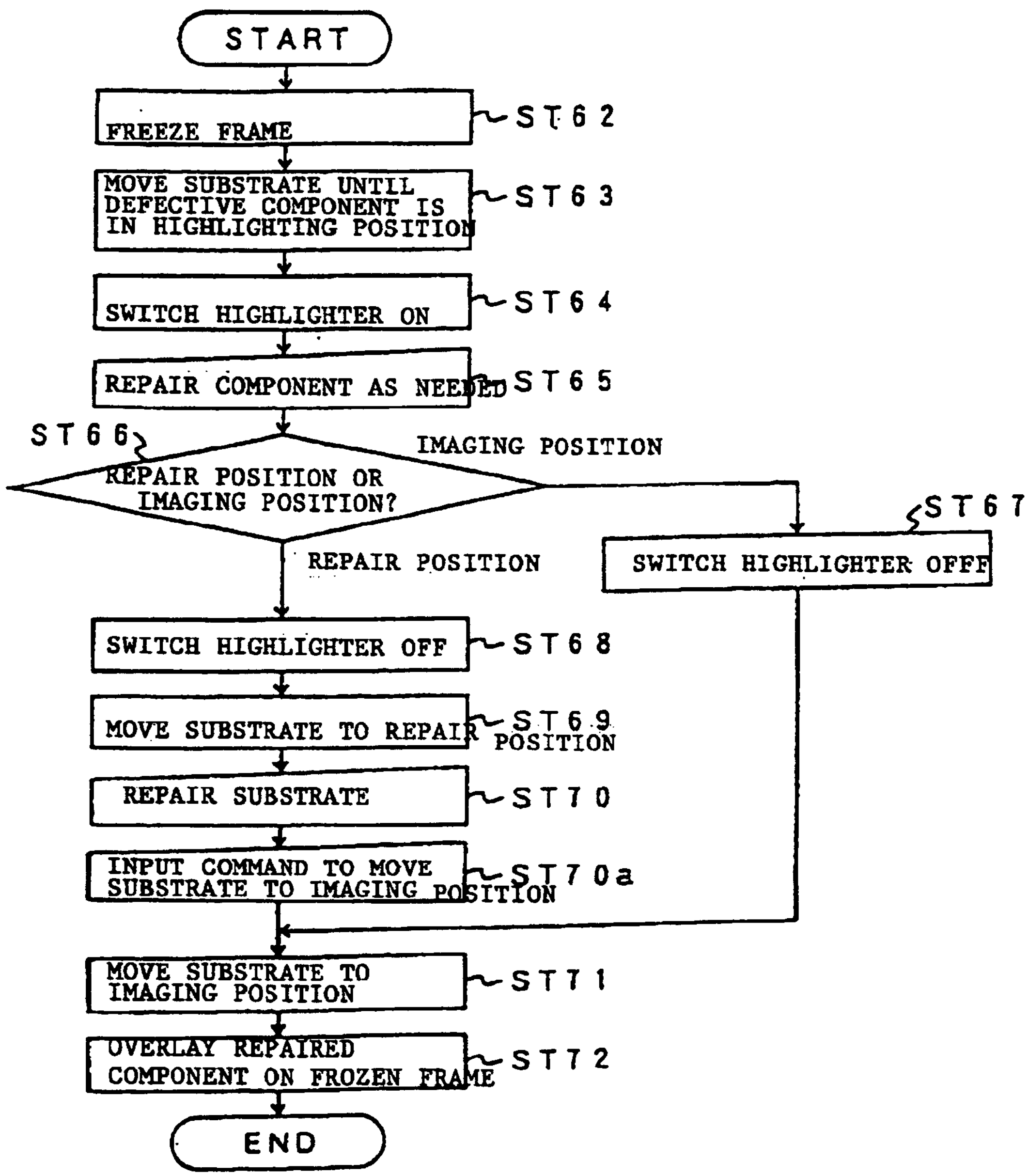
FIGURE 24



BNSDOCID: <EP___0723390A2_I_>

FIGURE 25



BNSDOCID: <EP___0723390A2_I_>

FIGURE 26

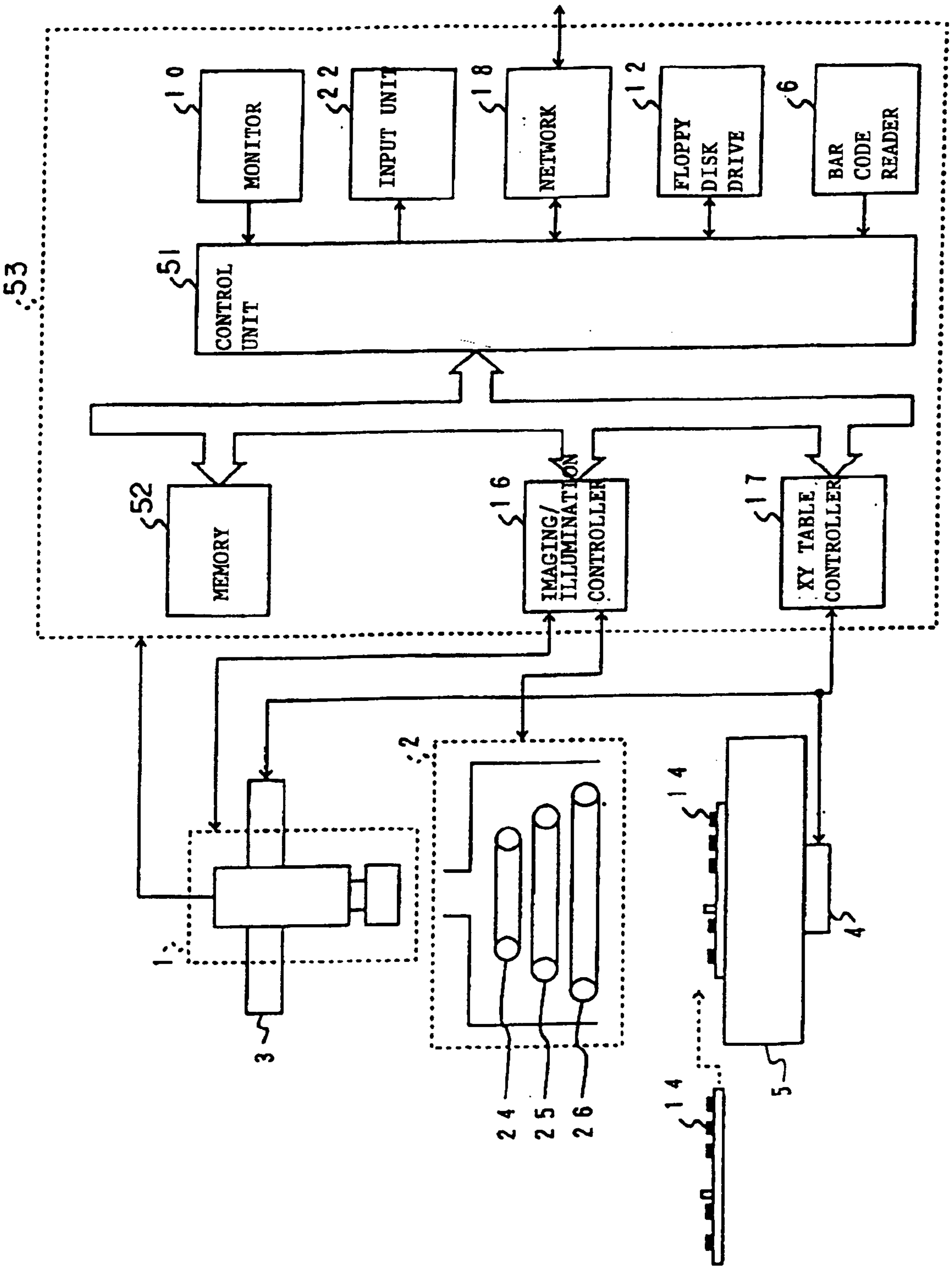


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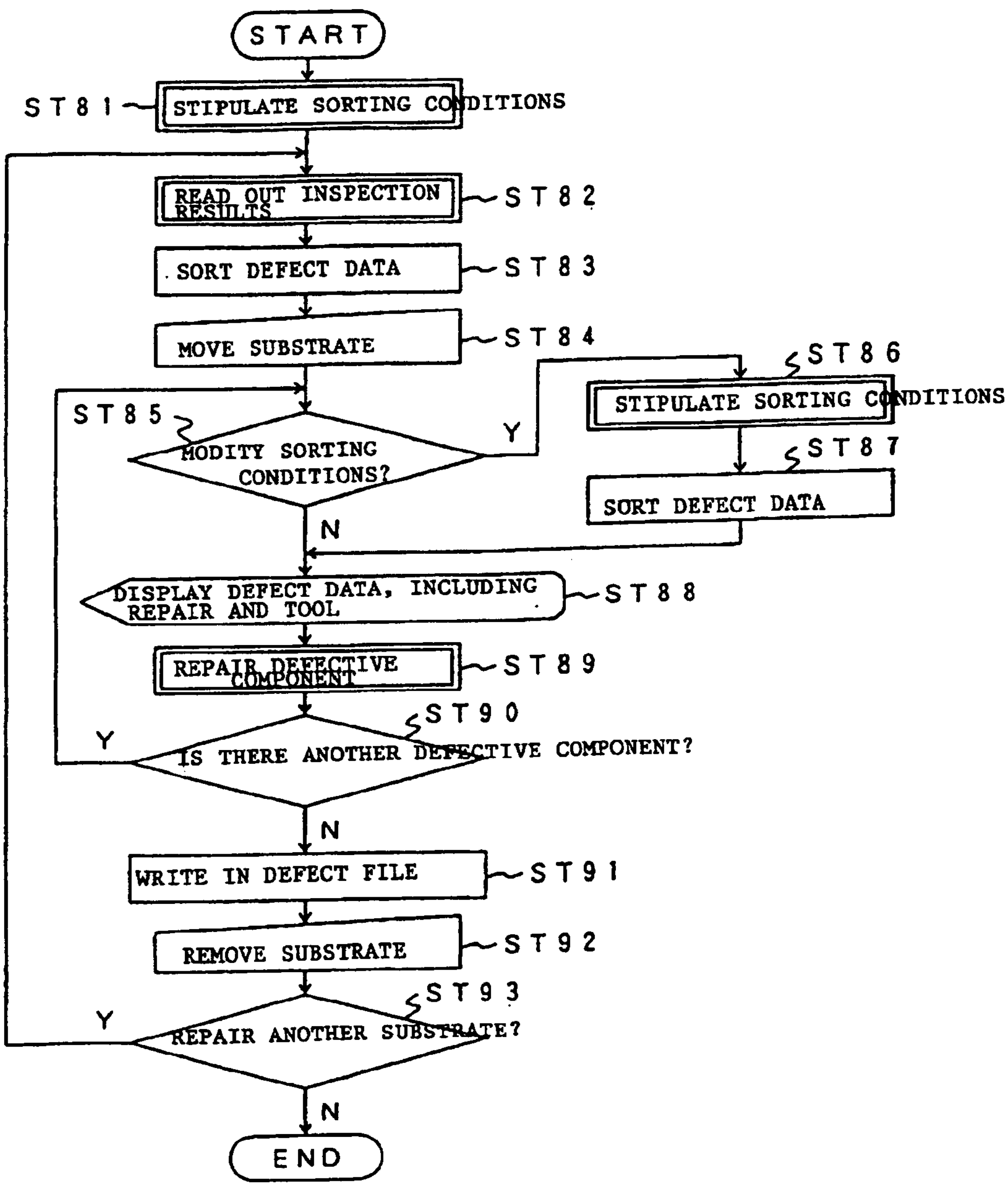
FIGURE 27



NSDOCID: <EP___0723390A2_I_>

FIGURE 28

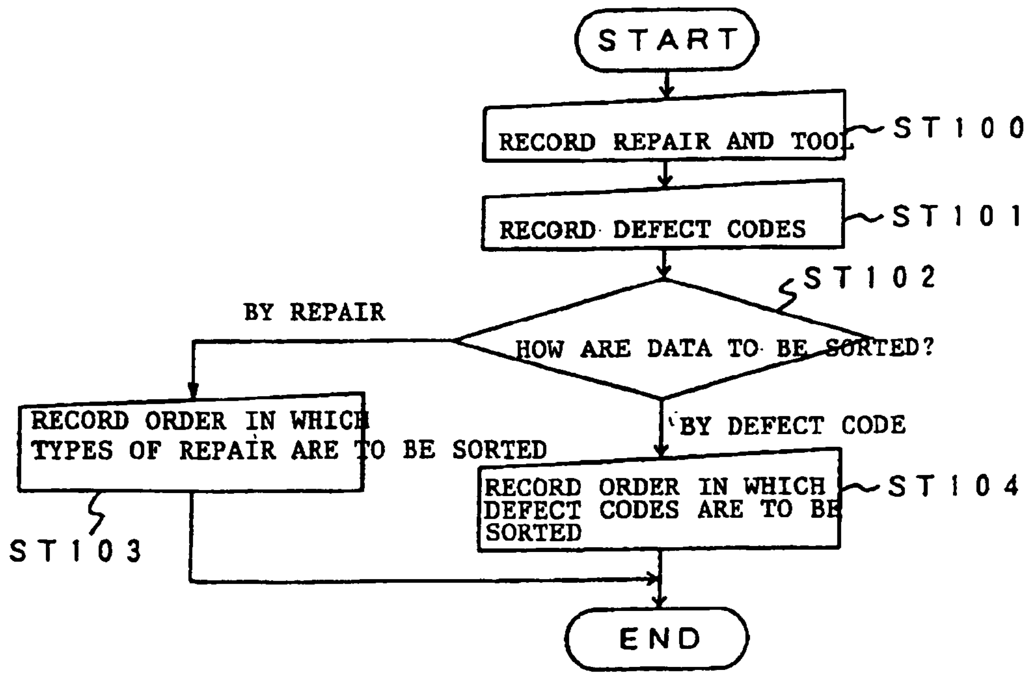


FIGURE 29

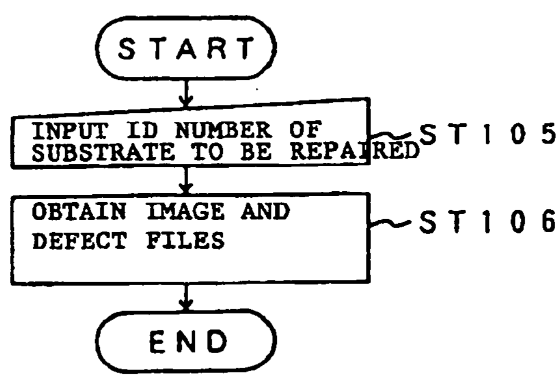


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FIGURE 30

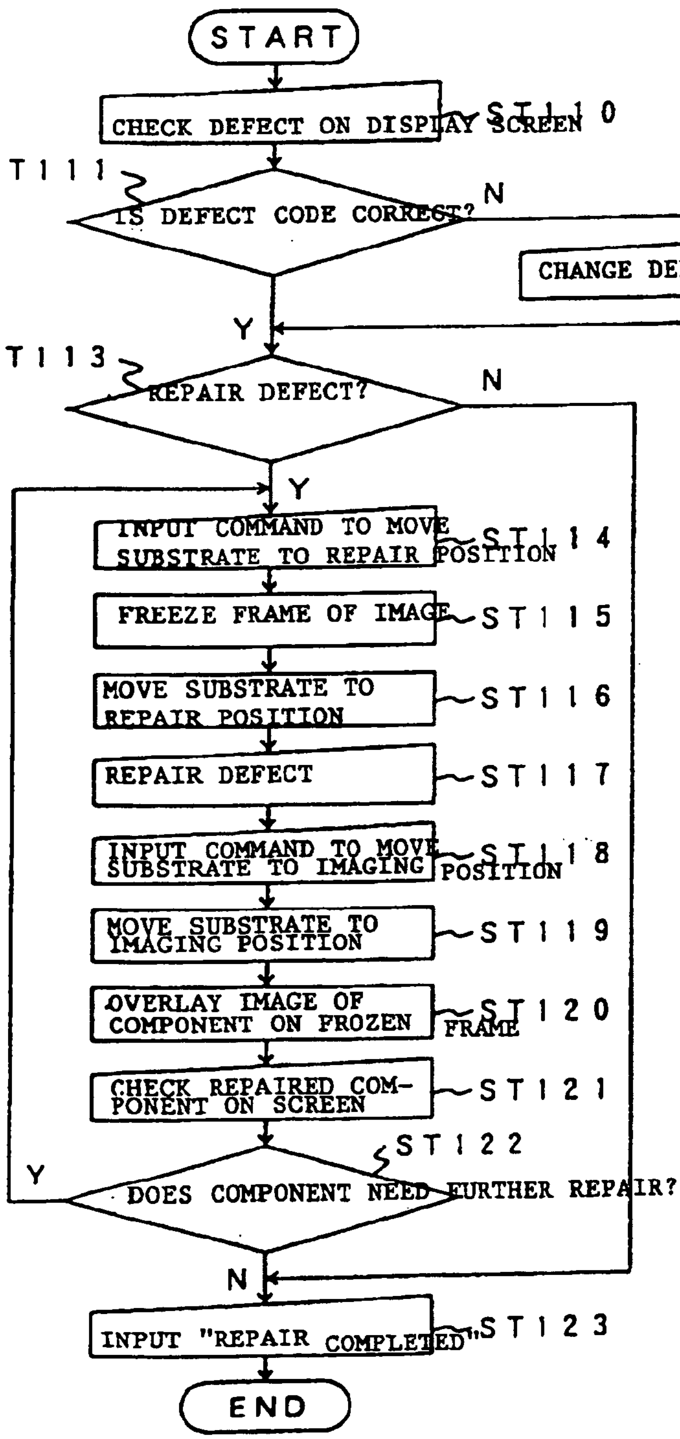

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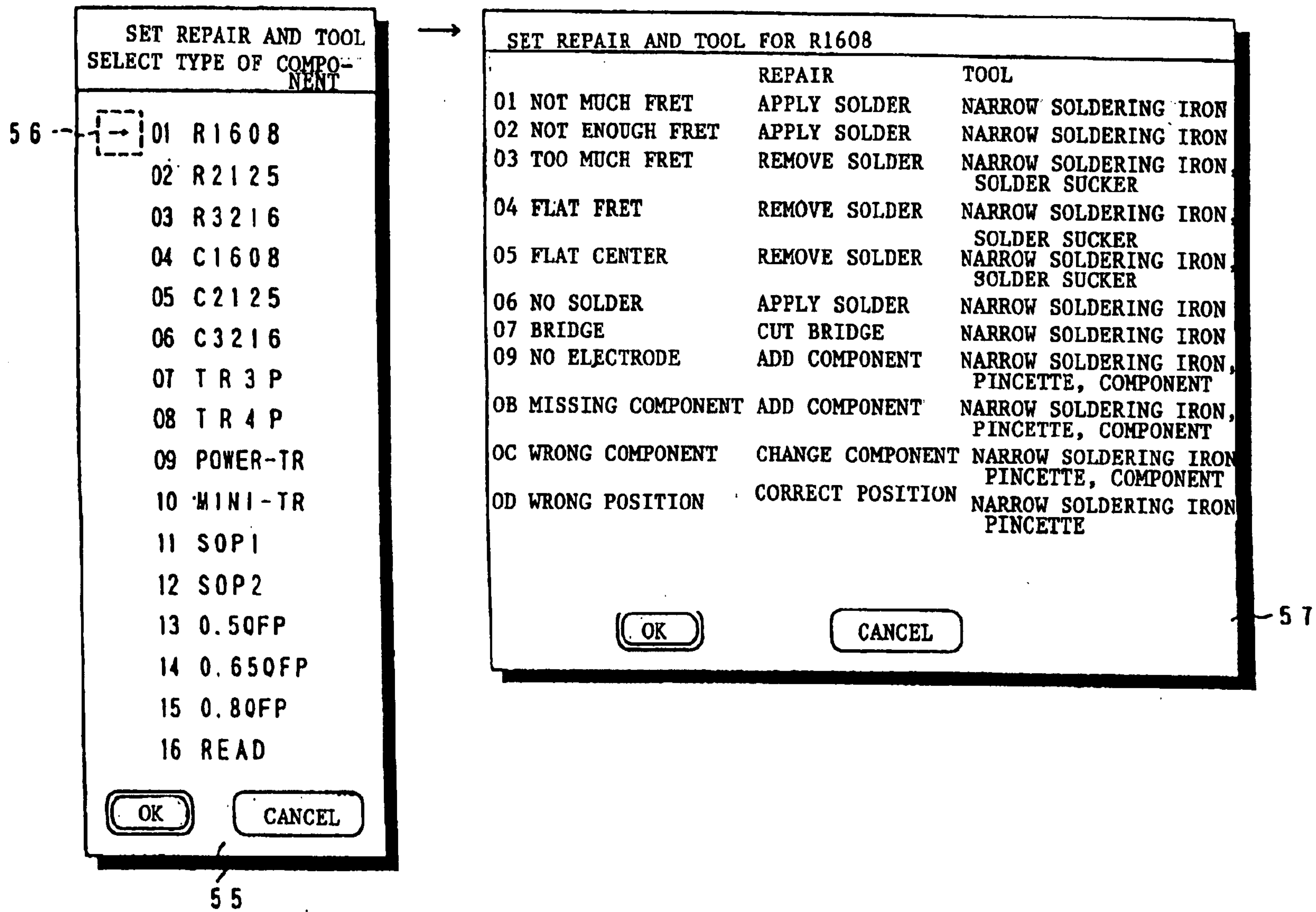
FIGURE 31



ENSDOCID: <EP___0723390A2_I_>

FIGURE 32

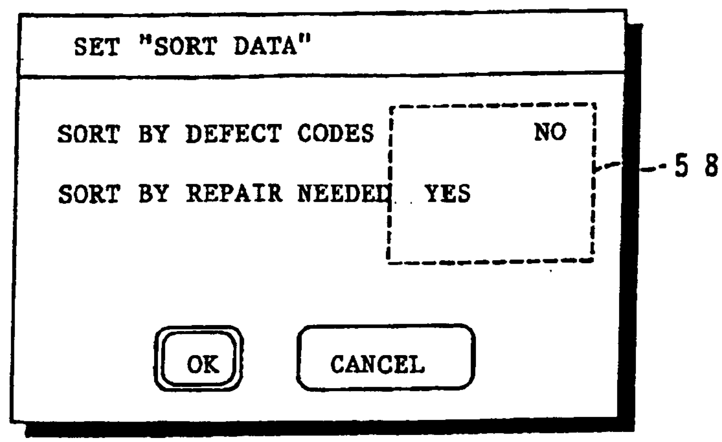
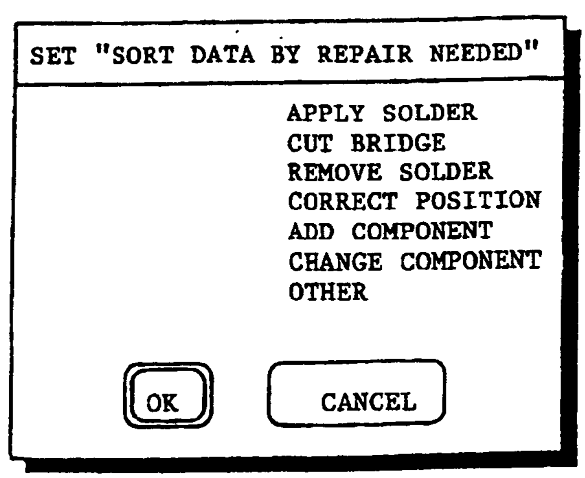


FIGURE 33



NSDOCID: <EP___0723390A2_I_>

FIGURE 34

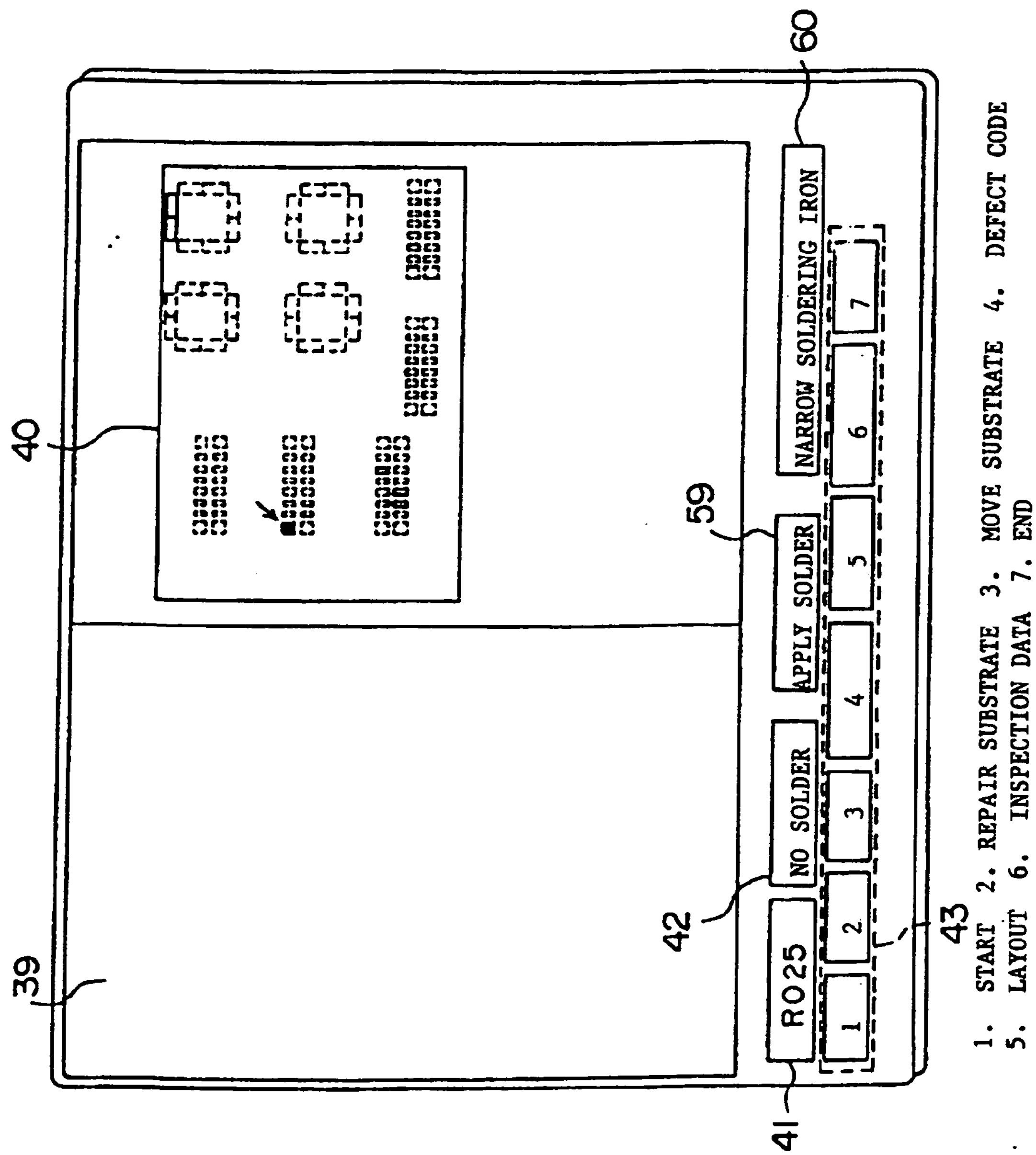


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FIGURE 35

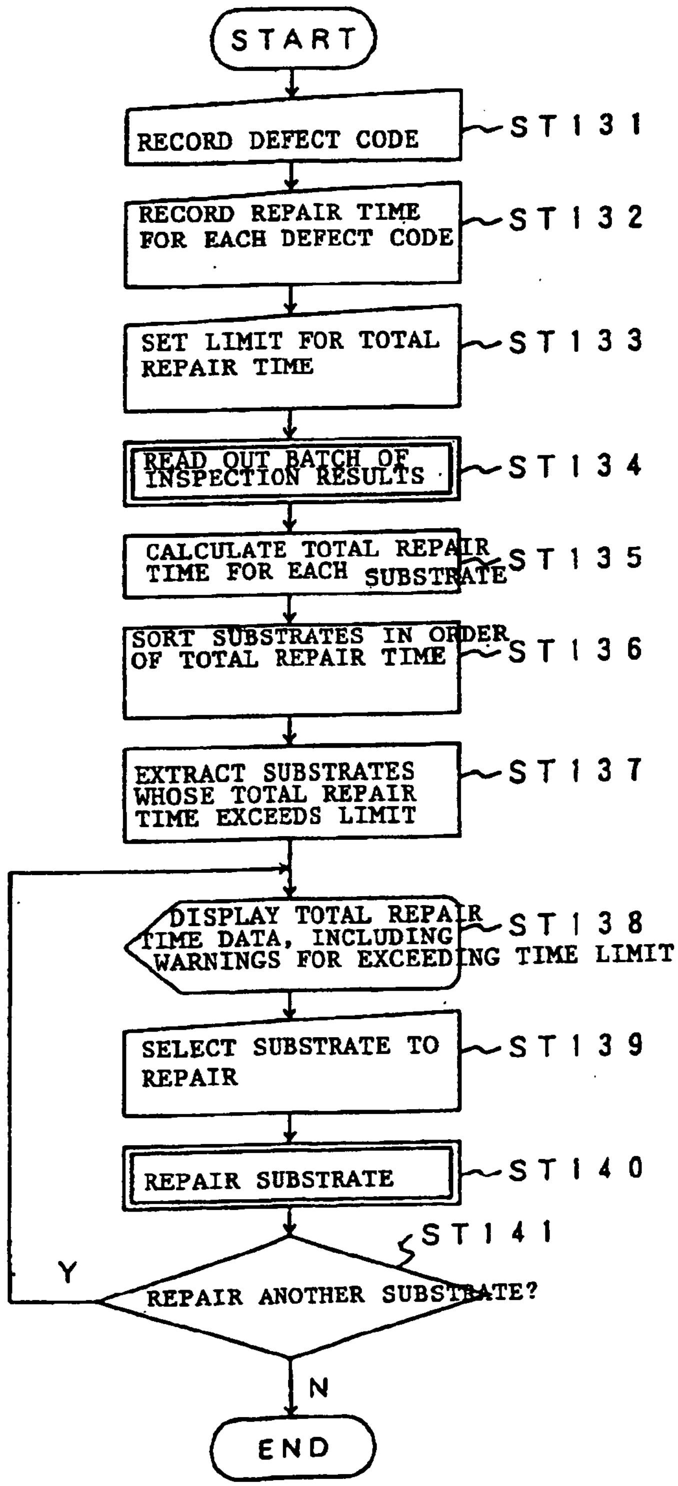

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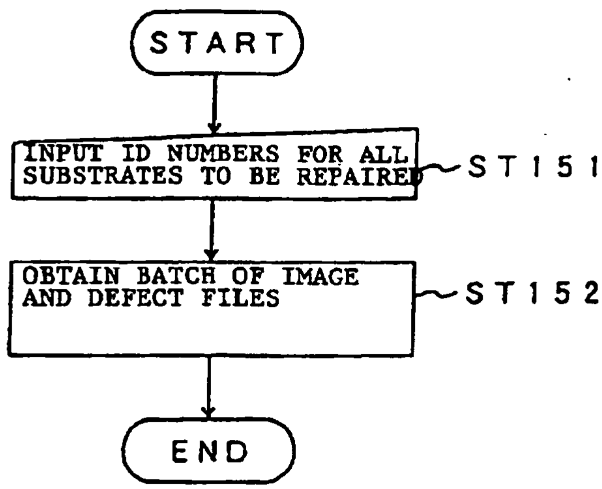
FIGURE 36



BNSDOCID: <EP___0723390A2_I_>

FIGURE 37

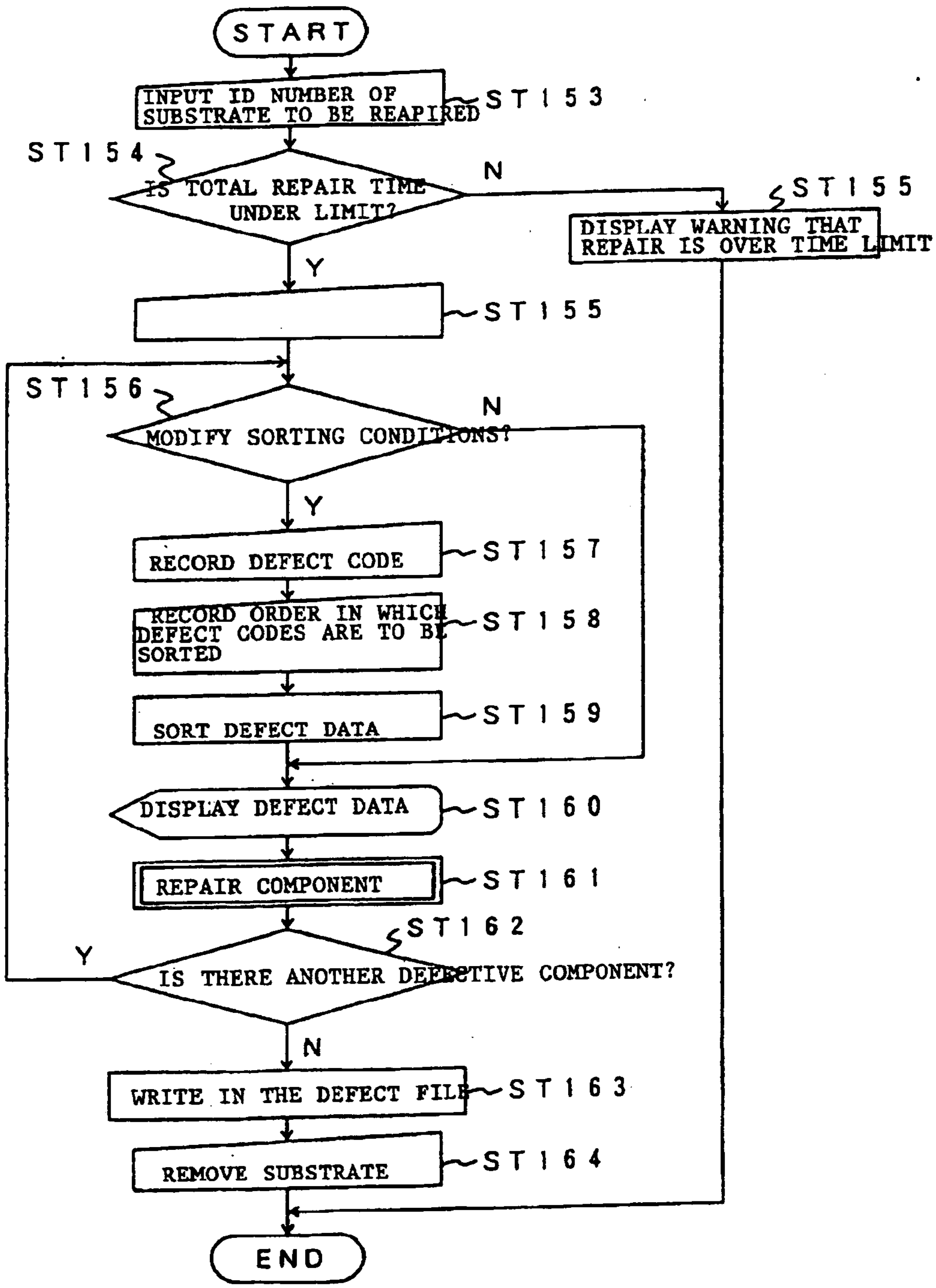


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FIGURE 38

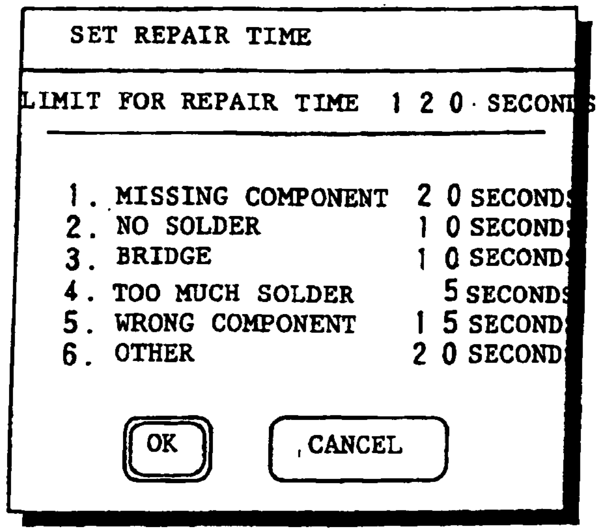

FIGURE 39

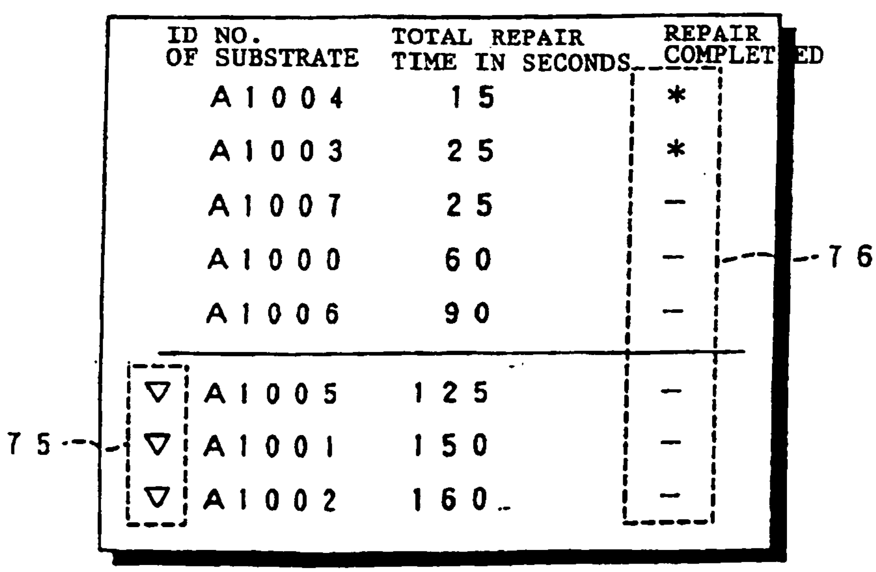

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FIGURE 40

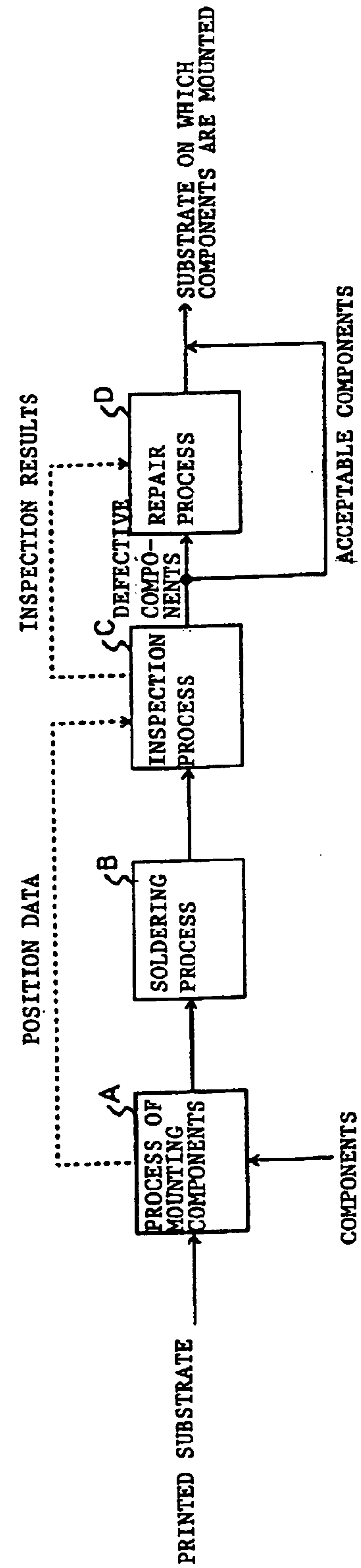

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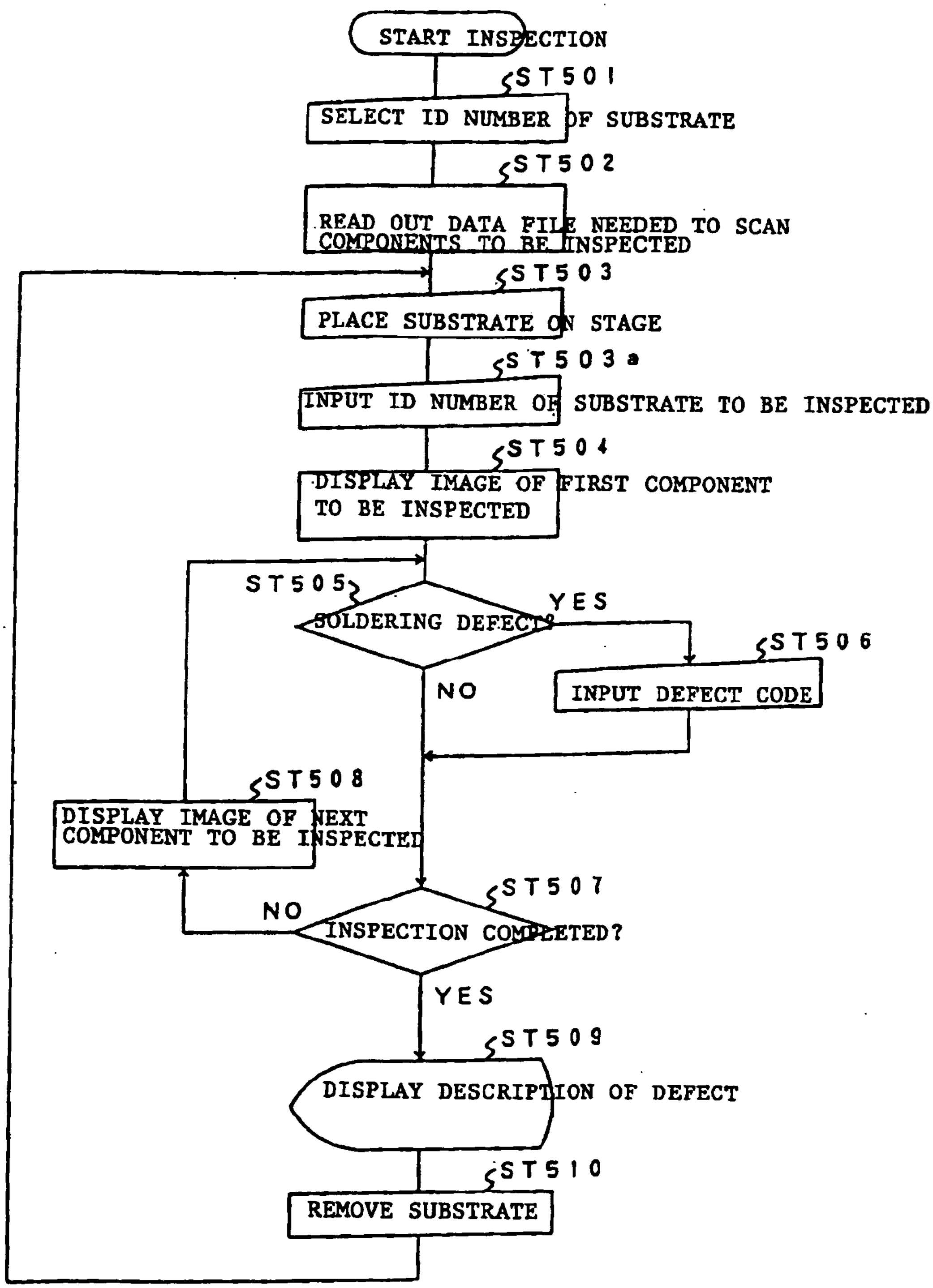
FIGURE 41



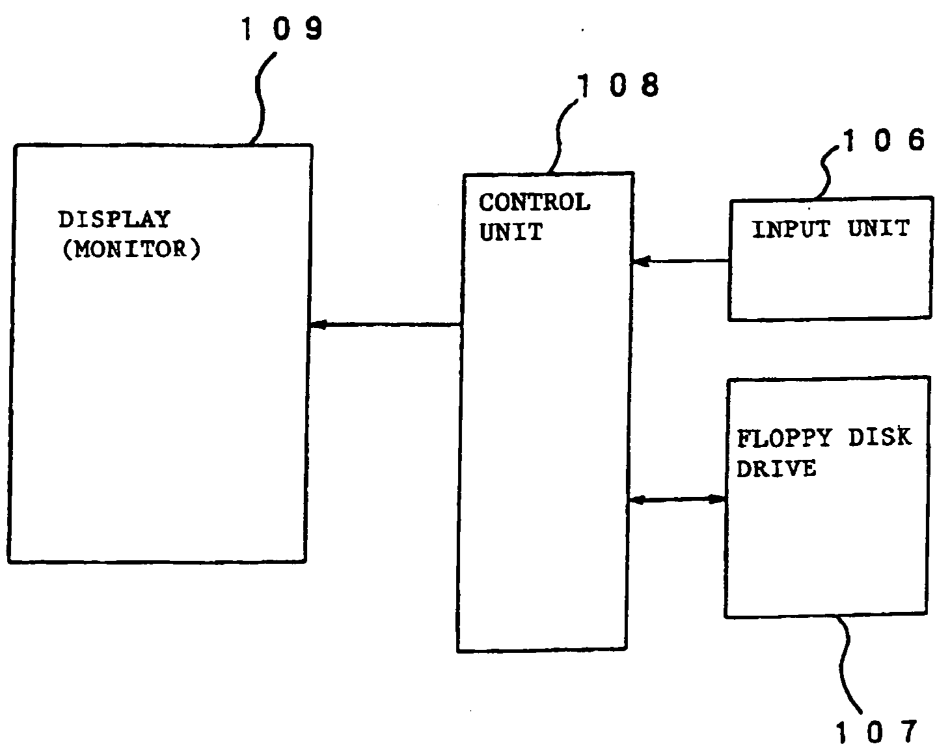
NSDOCID: <EP___0723390A2_I_>

FIGURE 42

PART NUMBER	PART ID CODE	TYPE OF COMPONENT	X COORDINATE OF COMPONENT	Y COORDINATE OF COMPONENT	DEFECT CODE
0035	R024	R1608	090000	050000	07
0036	R025	R1608	093000	050000	01
0038	C008	C2125	120000	055000	0D
0052	TR1	TR3P	070000	120000	07
0103	IC3-22	0.80FP	320000	250000	0B
0104	IC3-30	0.80FP	326000	250000	0A
.....	.....	.....	.....	.....	.....
101	102	103	104		105

NSDOCID: <EP___0723390A2_I_>

FIGURE 43



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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 723 390 A3

(12) **EUROPEAN PATENT APPLICATION**

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14.08.1996 Bulletin 1996/33

(43) Date of publication A2:
24.07.1996 Bulletin 1996/30

(21) Application number: **96100611.1**

(22) Date of filing: **17.01.1996**

(51) Int. Cl.^{6}: **H05K 13/04**, H05K 13/08

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DE FR GB

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11.04.1995 JP 109169/95

(71) Applicant: **OMRON CORPORATION**
Kyoto-shi, Kyoto 616 (JP)

(72) Inventors:
- **Yamamoto, Norihito**
  Ohtsu-city, Shiga-ken (JP)
- **Tanaka, Koichi**
  Kyoto-city, Kyoto-fu (JP)
- **Hisano, Atsushi**
  Kameoka-city, Kyoto-fu (JP)

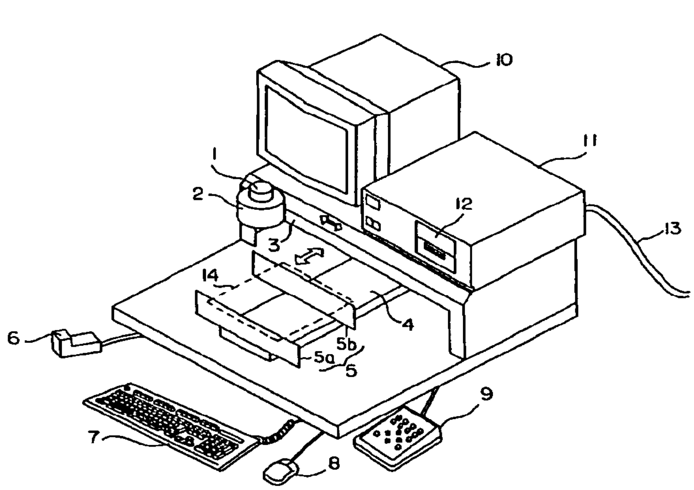
(74) Representative: **Kahler, Kurt, Dipl.-Ing.**
Patentanwälte
Kahler, Käck, Fiener et col.,
Vorderer Anger 268
86899 Landsberg/Lech (DE)

(54) **Method and device to support in the repair of defective substrates**

(57) This invention provides a method and device to support in the repair of substrates which would enable repairs to be performed efficiently.

A control unit (11) reads out of a floppy disk drive (12) or a network input/output unit the inspection results which include the defect file for substrate and stores them in a memory. This defect file is sorted into groups of components having the same defect code. In the order determined by this sorting, the defective components are moved by X-axis table (3) and Y-axis table (4) and imaged by imaging unit (1). The color image of each defective component is displayed on a monitor (10) along with its defect code. A layout diagram of the substrate is displayed to indicate the locations of the defective components. Components with the same defect code can be repaired consecutively.

FIGURE 1



EP 0 723 390 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 0611

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 304 943 (MÜT-GMBH) 1 March 1989 * column 3, line 29 - column 4, line 58; figure 1 * ---	1,2,8	H05K13/04 H05K13/08
A	GB-A-2 184 877 (TDK CORPORATION) 1 July 1987 * page 1, line 102 - page 2, line 27; figure 1 * ---	1	
A	EP-A-0 214 030 (DIGITAL EQUIPMENT CORPORATION) 11 March 1987 * column 3, line 9 - column 3, line 23; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H05K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 June 1996	Bolder, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

BNSDOCID: <EP___0723390A3_I_>